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A Summary of Current Program and
Preliminary Report of Progress

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SUGAR RESEARCH

CURRENT SERIAL RECORDS

of the

United States Department of Agriculture
and related work of the
State Agricultural Experiment Stations

This progress report is primarily a research tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of research progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C. 20250

December 15, 1965

ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources and Facilities Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research
12. Plant Science and Entomology Research
13. Tobacco Research

ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

Agricultural Research Service (ARS)

- 1 - Agricultural Engineering
- 1 - Soil and Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Clothing and Housing
- 3 - Consumer and Food Economics
- 4 - Market Quality
- 4 - Transportation and Facilities
- 7 - Animal Husbandry
- 7 - Animal Disease and Parasite
- 12 - Crops
- 12 - Entomology

Economic Research Service (ERS)

- 1, 5 - Economic Development
- 4, 5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Economic and Statistical Analysis
- 5 - Foreign Development and Trade
- 5 - Foreign Regional Analysis
- 5 - Natural Resource Economics
- 6 - Forest Service - Research (FS)
- 4, 5 - Farmer Cooperative Service (FCS)
- 4, 5 - Statistical Reporting Service (SRS)

SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the USDA program and progress for the following commodities and subjects:

- 6 - Forestry (other than Forest Service)
- 7 - Beef Cattle, Part I-a
- 7 - Dairy, Part I-b
- 7 - Poultry, Part I-c
- 7 - Sheep and Wool, Part I-d
- 7 - Swine, Part I-e
- 7 - Animal-Poultry and Products, Part II
- 8 - Cotton and Cottonseed
- 9 - Grain and Forage Crops
- 10 - Horticultural Crops
- 11 - Oilseed and Peanut
- 11 - Sugar
- 13 - Tobacco

A copy of any of the reports may be requested from Max Hinds, Executive Secretary, Oilseed, Peanut and Sugar Crops Research Advisory Committee, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250

INTRODUCTION

This report, which is prepared annually, deals with work directly related to the production, processing, distribution, and consumption of sugarcane, sugarbeets, and sweet sorghum. It does not include extensive cross-commodity work, much of which is basic in character, which contributes to the solution of not only sugar problems, but also to the problems of other commodities. Progress on cross-commodity work is found in the organizational unit reports of the several divisions.

The report covers Farm Research; Nutrition, Consumer and Industrial Use Research and Economic Research. As shown in the table of contents there is a breakdown of the research program by problem areas.

For each area, there is a statement of (1) the Problem, (2) USDA and Cooperative Program, (3) Program of State Experiment Stations, (4) A Summary of Progress during the past year on USDA and Cooperative Programs, and (5) a list of Publications resulting from USDA and Cooperative Programs.

Research on sugar crops is supported by (1) Federal funds appropriated to the research agencies of the U. S. Department of Agriculture, (2) Federal and State funds appropriated to State Agricultural Experiment Stations, and (3) private funds allotted, largely by sugar industries, to research carried on in private laboratories or to support of State Station or USDA work.

Research by USDA

Farm Research in the Agricultural Research Service comprises investigation on introduction, breeding, and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting and handling operations and equipment. It is carried out in the following divisions: Crops, Entomology, and Agricultural Engineering. The work involves 68 professional man-years of scientific effort.

Nutrition, Consumer and Industrial Use Research conducted in the Agricultural Research Service discussed in this report pertains to the chemical and physical properties, new and improved products, new and improved processing technology of sugar crops. The research was conducted by the following divisions: Northern, Southern, and Western Utilization Research and Development Divisions; Consumer and Food Economics, and the Human Nutrition Divisions. The work on sugar beets at the Western Utilization Division and work on sugarcane at both the Northern and Southern Utilization Divisions has been terminated. The continuing research effort involves 2.7 professional man-years.

Economic Research pertains to the organization and performance of markets with respect to market institutions and market power; prices, margins, and costs; and location and interregional competition. This work is conducted by the Marketing Economics Division of the Economic Research Service. Research in cooperative marketing is conducted by the Farmer Cooperative Service. The sugar research in these services involves 2.6 professional man-years.

Interrelationships Among Department, State and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the station. Cooperative work is jointly planned, frequently with the representatives of the producers or industry participating. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators, which frequently includes resources contributed by the interested producers or industry.

Research by industry and other organizations is sponsored primarily by beet and sugarcane companies, processors, sugar refiners, and chemical companies.

Beet sugar companies conduct applied research on breeding and genetics, nutrition, and agronomic practices, including production and processing of sugar beet seed. The Department supplies new varieties and conducts the basic research needed by the beet sugar companies in their research program.

Large companies that grow sugarcane in Florida, Louisiana, Puerto Rico, and Hawaii conduct research on breeding, variety evaluation, cultural practices, fertilization, and the use of chemicals to expedite (1) the accumulation of sugar in sugarcane and (2) harvesting operations. Valuable developments from such research is made available to Federal and State scientists who cooperate by conducting the basic research necessary to such activity.

Chemical companies conduct research for the development of more effective fungicides for the control of diseases which attack sugar crops and for seed dressings. Also some chemical companies are engaged in the formulation of chemicals for use as desiccants, as fungicides, as growth stimulants, and as retardants to hasten maturity of sugarcane. Federal and State groups provide the basic and fundamental phases essential to this area of research.

Basic research done by the Department and States will be utilized by industry and other organizations in their research programs, especially in the further development of improved products and equipment. Industry's cooperation in supporting sugar research at Federal and State Stations has contributed greatly to its success.

I. FARM RESEARCH

SUGAR PLANT CULTURE, BREEDING,
DISEASES, AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. Our sugar requirements are provided through quotas of domestic production and importations established by the Sugar Act. Sugar Crops have major problems pertaining to quality and efficiency of production that must be solved if our domestic quotas are to be maintained in competition with foreign sources of sugar. Problems of production have acquired broader significance with the implementation of the Sugar Act Amendment of 1962 which provides for growth and expansion of the domestic sugar industry.

Diseases of sugar crops, especially virus yellows of sugarbeet and ratoon stunting of sugarcane, affect quality and continue to take a heavy toll of production. The new strains of the curly top virus of sugarbeet and of the mosaic virus of sugarcane are capable of severely damaging varieties that are resistant to the strains formerly prevalent in a region. The major diseases, as well as new strains of the pathogens, are serious hazards of stable production of sugar crops in all regions of the country.

The bank of germ plasm of sugarcane and sweet sorghum has been greatly enriched through importation of breeding material, and the World Collections of these crop plants should be further utilized to develop productive varieties that are of high quality, resistant to diseases and insects, and tolerant to low temperature. Germ plasm is available which could provide factors for resistance to most of the major sugarbeet pathogens, including the cyst nematode. Breeding should be accelerated to utilize this wealth of germ plasm in the development of resistant lines, varieties, and hybrids.

Basic research is essential to a better understanding of genetic, cytoplasmic, and environmental factors conditioning male sterility in sugar crops and to provide information on techniques for the use of this character as a tool in the production of hybrid seed. The labor requirements for sugar production should be reduced through the development of varieties of sugar crops that are suitable for mechanized farming.

Information on the etiology and epidemiology of diseases of sugar crops is urgently needed for the development of methods of control through the application of direct measures, biological antagonism, and breeding for resistance. Soil-inhabiting pathogens attack the root systems of sugarbeet and of sugarcane, inflicting heavy losses; and the microbial flora of the rhizosphere may have a bearing on the failure of sugarcane plantings to endure repeated harvest and regrowth and on the decline in variety productivity.

Improved cultural and nutritional practices have resulted in a marked increase in acreable yield of both sugarbeet and sugarcane, but sucrose percentage has shown a downward trend. Expanded research is required to establish fundamental principles in physiology and genetics, whereby concomitant improvement can be brought about in both quality and yield under high levels of fertility. Quality research should be expanded to include post-harvest problems related to physiological changes that occur in storage and to losses due to spoilage.

PROGRAM--USDA AND COOPERATIVE PROGRAMS

Type of Research. The Crops Research Division has a continuing, long-term program of basic and applied research on sugarbeet, sugarcane, and sweet sorghum with 52.6 professional man-years devoted as follows: 22 to breeding and genetics, 12.1 to diseases, 8.8 to quality and variety evaluation, and 9.7 to culture and physiology. These man-years are distributed for crops as follows: Sugarbeet - 13.1 to breeding and genetics, 6.8 to diseases, 4.8 to quality and variety evaluation, and 4.3 to culture and physiology; Sugarcane and Sweet Sorghum - 8.9 to breeding and genetics, 5.3 to diseases, 4.0 to quality and variety evaluation, and 5.4 to culture and physiology.

Locations and Cooperation. In addition to research at Beltsville, Maryland, and at Federal Field Stations in California, Louisiana, Florida, Mississippi, and Georgia, investigations are conducted cooperatively under Memoranda of Understanding or Cooperative Agreements with State Experiment Stations on sugarbeet in California, Arizona, Utah, Colorado, Michigan, Minnesota, and New York and on sugarcane and sweet sorghum in Louisiana, Florida, Mississippi, Alabama, Georgia, Tennessee, South Carolina, Texas, Kentucky, and Puerto Rico.

Other Organizations. Cooperative sugarbeet work on contributed funds is conducted at Salinas, California; Logan, Utah; Fort Collins, Colorado; and Beltsville, Maryland, with the Beet Sugar Development Foundation; and at East Lansing, Michigan, and Beltsville, Maryland, with the Farmers and Manufacturers Beet Sugar Association; and at Salinas, California, with the Union Sugar Division, Consolidated Foods Corporation, and the California Beet Growers Association. Research on sugarcane and sweet sorghum is carried out in cooperation with the American Sugar Cane League in Louisiana and Florida, with the Cairo Cane Growers' League in Georgia, with the Hawaiian Sugar Planters' Association in Hawaii, and in Puerto Rico on funds contributed by the Association of Sugar Producers of Puerto Rico and the Land Authority of Puerto Rico. Sugarbeet breeding material is being tetraploidized in Spain, and research is being conducted on yellow wilt of sugarbeet in Chile and on Cercospora leaf spot in Israel under

Public Law 480 grants. In October 1963, a Public Law 480 Research Grant FG-IN-170 (A7-CR-1) was approved for research hybridization of U. S. and Indian sugarcane clones with Saccharum spontaneum and other species to develop cold-, disease-, and pest-resistant germ plasm suitable to evolve superior commercial varieties in the United States.

PROGRAM OF STATE EXPERIMENT STATIONS

Scientists at the State Experiment Stations are engaged in basic and applied research on plant breeding, plant pathology, plant physiology, and agronomy. The research is conducted cooperatively with the Department and with industry in the major sugar-producing States. This research is continuing to provide useful fundamental information for the improvement of sugar production.

The relationship between moisture supply to sugarcane and various physiological processes is being studied in Hawaii. The use of sugarcane for forage is being explored in Florida. Dates of harvest and post-ripening chemical treatments are being studied for their effect on sucrose content and purity. Breeding of sugarcane involves testing of varieties for adaptation in several States. A collection of germ plasm is being assembled and maintained in Puerto Rico. The alcoholic, lactic, and citric fermentation of molasses is being studied in Puerto Rico to increase the efficiency of molasses utilization.

Sweet sorghum varieties are being evaluated for local adaptation for sirup production in several States.

Research on sugarbeet involves preplanting tillage, cultivation, trace elements, rotations, and the relation of sucrose content of sugarbeet to soil fertility, nitrogen fertility, environmental factors, cultural practices, and nutrient levels indicated by plant tissue tests. Some breeding for resistance to diseases is in progress. Several States are evaluating varieties and cultural practices to determine the feasibility of establishing new sugarbeet areas.

Scientists in the States are conducting research on many of the disease problems of sugar crops. On sugarcane, three research projects concern the role of nematodes in disease problems. Recent findings in this work have contributed new knowledge on the effect of the clover cyst, ring, stunt, spiral, stubby root, and lesion nematode on sugarcane.

Basic studies using tissue culture techniques promise to provide new insight into the biochemical specifics of selected nema deprecations, and thus contribute not only to eventual improvement in disease control in sugarcane but also to biological science in general. Other scientists are concerned with research on the destructive mycoses of sugarcane, such as those caused by Cytospora, Phytophthora, and a number of other fungi. Portions of this research are also designed to develop new techniques for the isolation of germ plasm resistant to these diseases. Some research projects involve studies on virus diseases of sugarcane such as ratoon stunting and mosaic. New findings on seedcane transmission of the ratoon stunting disease, the interaction of viruses, and on serological identification of viruses are significant contributions.

Research on sugarbeet diseases concerns Aphanomyces root rot, Rhizoctonia blight, Cercospora leaf spot, beet yellows, beet mosaic, and Fusarium root rot. New strains of the beet mosaic virus have been isolated, which will aid in the analytical procedures used for obtaining resistance. Host range of this virus and development of an effective antisera for the yellow dwarf virus are phases of the work being pursued in two research projects. Studies on the use of soil fumigants for the control of nematodes and fungi that attack sugarbeet are contributing new knowledge on microbial interactions and on the role of selected metabolites in pathogenesis. Studies on Cercospora disease have resulted in the biochemical characterization of two components contributing resistance to this disease. Related research on the role of bacteria in fungal root rot of beets is providing new useful concepts for investigations of many diseases. A few studies are directed toward the use of crop residues and specific chemicals to control diseases of sugarbeet.

The total research effort is approximately 30.1 professional man-years; of which 8.6 is for culture, 10.5 for breeding and genetics; 7.2 for diseases, and 3.8 for varietal evaluation.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Breeding and Genetics
a. Sugarbeet

1. Regional Adaptation. The 1962 Amendment to the Sugar Act provided sugar marketing quotas for six new areas of sugarbeet production. The allocations have been awarded and factories are now under construction or have been completed at Mendota, California; Phoenix, Arizona; Hereford, Texas; Drayton, North Dakota; Auburn, New York; and Easton (Aroostook County), Maine. The research needs of these districts required redirection of sugarbeet breeding to meet new hazards as well as combinations of old ones. Both curly top and leaf spot may reach epidemic proportions in Texas and the Great Plains region, also curly top and virus yellows in Arizona and California. Extreme bolting resistance is required for varietal adaptation in New York and Maine.

Results of 1964 tests indicate that the "US" monogerm hybrids produced for the Pacific Coast and Southwestern States are similar in root yield and sucrose percentage, but differ in bolting and curly top resistance. Several new monogerm inbreds and their male-sterile equivalents have been developed that are as curly top resistant as the best multigerm lines, and a tetraploid line has been established that is as curly top resistant as diploid hybrids and superior to them in bolting resistance. Triploid hybrids tend to be superior to diploids in bolting resistance and root yield, but inferior in seed germination and sucrose percentage. Hybrids of the two ploidy levels were similar in curly top and virus yellows resistance.

2. Monogerm Seed. Monogerm varieties that facilitate mechanization and reduce labor requirements of sugarbeet production have essentially replaced multigerm sorts in the United States. Monogerm hybrids and varieties comprised 88.5 percent of the seed crop in 1962, 86.8 percent in 1963, and 88.2 percent in 1964. The small percentage of multigerm seed is grown for export and for use as pollinator in hybrid seed production. The monogerm varieties and parental lines are being improved in productivity and regional adaptation. The genetic transfer of the remarkable seed character from a single monogerm plant, which was found in 1947, to varieties that are adapted to all sugarbeet districts in this country is an outstanding accomplishment of the U. S. Department of Agriculture and cooperators in the beet sugar industry and in seed-producing enterprises. Progressive growers and innovators are using monogerm seed and precision planters to obtain the desired plant populations as seedlings and thereby remove the need for singling. The development of monogerm varieties that facilitate mechanization and reduce the requirements of hand labor may prove to be the savior of the beet sugar industry in the United States.

3. Haploid Sugarbeet. Scientific and experimental value is attached to the production of a new diploid line of sugarbeet that is completely uniform in genotype. A plant was found having only nine chromosomes typical of the gametes (sex cells) of a diploid sugarbeet as opposed to the typical somatic (vegetative tissue) number of 18. The haploid plant was sterile. Colchicine treatment doubled the chromosome complement in the plant and induced sexual fertility. The diploid progeny of this haploid is now in culture and provides, for the first time, plants that are completely uniform in genotype for genetic research and for experimentation. The potential value of diploidized haploids in sugarbeet improvement is being studied.

b. Sugarcane

New varieties of sugarcane having high sugar content, resistance to diseases and insects and to cold damage, and adapted for mechanical harvesting are developed through breeding research at Canal Point, Florida; Houma, Louisiana; Meridian, Mississippi, and Cairo, Georgia. Most of the parental clones are superior selections from progenies of former crosses; some special crosses were made in 1964 to broaden the genetic base and provide material for studying the inheritance of important varietal characteristics. In the 1964-1965 crossing season, 319 crosses made at Canal Point provided approximately 400,000 viable seed to produce more than 250,000 seedlings for field evaluation in Louisiana, Florida, and the sirup-producing areas. Approximately 60% of the seedlings in Louisiana were discarded because of susceptibility to mosaic.

1. New Germplasm. Research at Canal Point and Houma to develop new germplasm for the breeding program provided about 18,000 seedlings from interspecific and intergeneric crosses for evaluation under field conditions. Approximately 50,000 seedlings from interspecific crosses made in India under P.L. 480 project A7-CR-1 are being evaluated for resistance to mosaic and the ratoon stunting disease.

2. Selections. More than 9,000 sugarcane seedlings were selected in Louisiana, Florida, Mississippi, and Georgia during 1964 for further, more critical, evaluation. The selection rate of superior seedlings ranges from 10 to 15 percent of the original units indicating that rigid screening for mosaic susceptibility did not seriously affect agronomic types of surviving seedlings. Evaluation of these promising selections under a range of environmental conditions is in cooperation with Agricultural Experiment Stations in Louisiana, Florida, Georgia, Mississippi, and Puerto Rico, the American Sugar Cane League, the Cairo Cane Growers' League, the Association of Sugar Producers of Puerto Rico, and the Land Authority of Puerto Rico.

3. Crossing Techniques. The technique of maintaining tassels of parental clones during the crossing process at Canal Point was improved greatly by using de-ionized water in preparation of the weak acid solution commonly employed for this job. When tap water was used, the tassels died in approximately seven days; but they lived 15 days when the de-ionized water was used in preparing the solution.

4. Genetic Studies of the Mosaic Virus. Efficient techniques have been developed at Beltsville through appropriate use of buffer solutions, filtration, column fractionation, and centrifugation for purifying and concentrating the mosaic virus in juice of infected sugarcane plants. This process, essential for dilution of the virus particles for genetic research, needs additional refinements for complete removal of chlorophyll components; further research is in progress to attain the objective.

5. World Collection. The World Collection of five species of Saccharum, special hybrids, and related grasses comprises more than 2,000 clones of valuable germplasm; twenty imported clones were added during 1964-1965.

c. Sweet Sorghum

Varieties of sweet sorghum superior in yielding ability, quality of juice for sugar and sirup production, and resistance to diseases are developed by breeding at Beltsville, Maryland; Meridian, Mississippi; Cairo, Georgia; and Brawley, California.

1. Hybrid Varieties. Preliminary data collected at Meridian, indicate that a few plants of the varieties Brawley, Rex, and Tracy have the inhibitor genes (male sterility factor) necessary in the production of hybrid varieties for commercial culture. Further investigations may make it possible to produce hybrid varieties having superior yielding qualities.

2. Irradiated Seed. Data from more than fifty selections of sweet sorghum from irradiated seed indicate minor differences in germination and in juice quality, but none of these changes were significantly better than the non-irradiated material.

3. Isogenic Lines. Several isogenic lines of the sweet sorghum variety Tracy produced higher yields of sirup per acre than Tracy. There was a significant improvement in the quality of sirup of eight of these isogenic lines; further research will be carried out with this material.

4. World Collection. A systematic procedure for evaluating more than 4,500 varieties in the World Collection of sweet sorghum for resistance to diseases, zonate leaf spot, red rot and bacterial stripe, was initiated at Beltsville and Meridian during the year.

B. Diseases
 a. Sugarbeet

1. Cercospora leaf spot. A leaf disease which is caused by Cercospora beticola has been prevalent in sugarbeet districts east of the Rocky Mountains for many years. The greatest damage has occurred in the Great Lakes region or in districts where the sugarbeet is grown under natural rainfall. Breeding research established resistant multigerm varieties and maintained an acceptable control of the disease. The labor-reducing potential of monogerm varieties brought them into use before a high level of resistance to the leaf spot pathogen had been established. Fungicide trials in Minnesota with varieties presently in use demonstrated that under moderately severe epidemics of Cercospora leaf spot, disease damage was significantly reduced. Although applications of fungicides from ground-operated sprayers were more effective than spraying from air (helicopter), under severe disease exposure four applications of fungicide from a helicopter showed a gain in value of root yield that was more than double the cost of the applications. Until a higher level of resistance to Cercospora beticola has been established in monogerm varieties of sugarbeet, large acreages will be treated with fungicide to reduce damage from the leaf spot disease.

2. Rhizoctonia Root Rot. A root disease of sugarbeet which is caused by Rhizoctonia solani occurs in all regions of production. The pathogen may attack plants in all stages of growth, but the rotting induced in roots of mature plants late in the growing season is the most important manifestation of the disease. Crop rotation, the usual recommendation of control, is not always effective; and search for resistant germ plasm has been conducted. The results of plant inoculation in field trials from 1956 through 1964 established that resistance to the pathogen occurs in cultivars of sugarbeet and that selection for resistance resulted in measurable improvement. A method of inoculation that will enable the breeder to screen sugarbeet populations for resistance and select resistant plants has been developed. Although none of the lines that have been evaluated carries sufficient resistance to produce a satisfactory crop under severe exposure to the disease, promising parental material has been established; and effective methods of disease exposure have been developed. Control of Rhizoctonia root rot through breeding to develop resistant varieties is feasible, and such work is underway.

3. Virus Diseases. A disease complex known as virus yellows continues to take heavy toll of sugarbeet production in California and the Pacific Northwest. This disease of sugarbeet was known in Europe many years before it was found in the United States. As in the United States, virus yellows of Europe is known to be caused by at least two viruses which differ in severity of damage. The hazards of importing pathogens for research have prevented direct comparisons between European and American

viruses. Extensive study of host range and symptom expressions has established beyond reasonable doubt that the mild yellows of England is caused by the same virus entity as beet western yellows in the United States. Therefore, varieties bred for resistance to the virus in England should be resistant to the beet western yellows in the United States.

Studies have indicated that the curly top virus is not a stable entity and that strains more virulent on sugarbeet are being discovered in widely separated areas. The discovery of two or three additional strains of the curly top virus in 1964, one capable of causing severe damage to cucumber and another to Chenopodium murale, representing species of plants on which symptoms had not previously been known, lends support to the theory that new strains of the virus are being produced under natural conditions.

b. Sugarcane

Two diseases of sugarcane, mosaic and the ratoon stunting disease, cause significant reductions in yields of cane and of sugar in Louisiana and Florida. The two diseases are apparently related to the decline in yield of sugarcane varieties. Most of the current pathological research relates to these two diseases.

1. Mosaic. Mosaic is now a major disease problem in the Louisiana sugarcane industry. The disease had increased in commercial fields in all areas of the industry; and in some cases, more than 50% of the plants are infected. Control of the disease by roguing is not generally effective; however, in some areas where the job has been done carefully, the percentage of infection is low. Varietal resistance is the only real control for the disease. Effective industry-wide control with resistant varieties is not apparent at this time. Studies are in progress in Louisiana and Florida to identify varieties of the World Collection that are resistant to known strains of the disease. Data from Meridian, Mississippi, indicate that sugarcane seedlings susceptible to mosaic under field conditions are also susceptible to mechanical inoculation. Susceptibility of seedlings to infection varies under both conditions in accordance with age at the time of mechanical or vector inoculation. Further studies are in progress in Mississippi and Georgia to increase efficiency of elimination of mosaic susceptible seedlings in the varietal improvement program.

2. Ratoon stunting disease. Data from plant cane and stubble experiments at Houma show that yield from seedcane free of the ratoon stunting disease (RSD) ranged from 2.1 to 26.7% higher than those from infected seedcane. C.P. 52-68, one of the leading varieties in Louisiana is tolerant to RSD. The new variety, C.P. 53-1, is very susceptible to RSD, which markedly reduces its yields. Inoculations at Meridian with the RSD virus failed to produce symptoms of infection in sweet sorghum. In Florida,

the substrate leachate of soil had a pH of 5.85 when sugarcane plants were healthy and 6.05 when plants were inoculated with RSD. Further research is needed to verify this observation. Preliminary studies at Meridian indicate that permeability of cells of sugarcane tissue infected with the RSD virus is lower than that of normal cells.

c. Sweet Sorghum

1. Zonate leaf spot (Gloeocercospora sorghi). Studies are in progress at Meridian, Mississippi; Houma, Louisiana; Cairo, Georgia; and Beltsville, Maryland; to evaluate new lines of sweet sorghum and varieties in the World Collection for resistance to zonate leaf spot. Limited data indicate that resistance in young plants differs from resistance of plants as they approach maturity. Techniques have been developed for effective artificial infection of young sweet sorghum plants with the causal organism.
2. Red rot (Colletotrichum graminicola). New varieties of sweet sorghum imported from other countries and maintained in the World Collection are screened for susceptibility to red rot at Beltsville, Maryland, and Meridian, Mississippi. During the screening for red rot at Beltsville, plants are also inoculated with bacterial stripe (Pseudomonas andropogoni (E.F.Sm.) Stapp.). Field conditions at Beltsville are favorable for screening for the two diseases, simultaneously.

C. Quality and Varietal Evaluation

a. Sugarbeet

1. Regional Variety Tests. Cooperative field trials conducted in the Great Lakes region demonstrated the excellent performance of hybrids in which SP 5822-0 was used as pollen parent. This pollinator has been bred for excellent quality and the character tends to be transmitted to its offspring. A new 3-way hybrid in which SP 5822-0 was the pollinator gave outstanding performance in root yield and sucrose percentage. This hybrid combination is being increased for commercial use.

Expansion of sugarbeet production in the Great Plains region, where both curly top and leaf spot may reach epidemic proportions, presents a greater demand for varieties that carry resistance to these diseases. In regional variety tests, emphasis has been given to monogerm hybrids and especially to those whose parentage would tend to enhance disease resistance. A group of four hybrids which involved FC 502 and FC 503/2 gave a gross sucrose yield that exceeded the check variety by 14.5 percent, a highly significant amount.

b. Sugarcane

Varieties of sugarcane developed in the breeding program at Canal Point, Florida, are evaluated for yield, sugar content, and disease and cold resistance in cooperation with Agricultural Experiment Stations in Louisiana, Florida, Mississippi, Alabama, Puerto Rico, the American Sugar Cane League, the Cairo Cane Growers' League, the Association of Sugar Producers of Puerto Rico, and the Land Authority of Puerto Rico. In 1964, varietal evaluations on more than a dozen soil types and growth conditions indicated the superiority of three varieties, C.P. 60-23, L. 60-1, and L. 60-25, for commercial culture in Louisiana and three, C.P. 56-59, U.S. 59-16-1, and C.P. 57-603, in Florida. Further tests are needed in Florida to effectively evaluate these promising varieties under a range of growing conditions.

1. Cold-resistant varieties. Laboratory experiments at Houma, Louisiana, indicate that Cl. 47-83 and N.Co. 310 were damaged least when exposed to a temperature of 24 degrees F. for 13 hours. C.P. 44-101 under similar conditions was damaged less than 10 percent. In Mississippi, a minimum temperature of 34° F. produced cold chlorosis on some varieties; a temperature of 31° F. damaged leaf tips. When the temperature dropped to 21° F., the upper part of the stalks was frozen. Temperatures in the fields at Meridian, Mississippi, provide favorable conditions for studying the resistance of varieties to cold damage.

2. New Varieties. The new variety, C.P. 55-30, produced higher yields of sugar per acre than the standard commercial variety, C.P. 52-68, in Louisiana. This relationship was observed on light and heavy soil. Two unreleased varieties in Louisiana, L. 60-25 and C.P. 60-23, produced yields of sugar per acre that were superior to those from C.P. 52-68. In Florida, C.P. 56-59, U.S. 59-16-1, and C.P. 57-603, were superior to Cl. 41-223, the standard commercial variety, in yield of sugar per acre. Further information is needed about stubbling qualities of C.P. 57-603, which appears to be best adapted to warm-land areas.

c. Sweet Sorghum

Sweet sorghum varieties developed in breeding programs at Beltsville, Maryland, and Meridian, Mississippi, are evaluated in cooperation with Agricultural Experiment Stations in Louisiana, Alabama, Georgia, South Carolina, Kentucky, Mississippi, Tennessee, and Texas. Varieties are evaluated on more than twenty soil types under a wide range of growth conditions, for sugar and sirup production.

1. New Varieties. A new variety, Rio, developed at Meridian and promising for sugar production in Texas, Louisiana, and other similar areas, was released for commercial culture in January 1965; the variety is highly resistant to diseases. Mer. 61-8, unreleased variety, is promising for sugar production in Mississippi. Mer. 59-1 is promising for sirup production in Tennessee, Mississippi, Alabama, and similar areas.

D. Culture and Physiology

a. Sugarbeet

1. Seed Ripeness. Studies on seeds harvested at 5-day intervals from the same plants revealed a very limited latitude in dates of harvest for highest quality. Harvest of immature seeds adversely affects the percentage germination with the most pronounced effect being a reduced speed of germination. The degree of ripeness of the fruits markedly affects water absorption and thereby the inhibitory action of chemical substances in the fruit on seed germination.

b. Sugarcane

1. Growth of Varieties. Varieties of sugarcane differed significantly in rate of growth under similar conditions at Houma, Louisiana, in 1964. N.Co. 310 grew slower than other varieties. C.P. 55-30 grew rapidly early in the season, but the rate of growth was slow during the latter part of the season; it was exceeded by C.P. 52-68 in this respect. Damage from hurricane Hilda in October caused abnormal growth during the harvesting season with extensive germination of buds in standing cane.

2. Fertilization. In Louisiana, yields of cane per acre from application of 120 pounds of nitrogen were 0.76 ton higher than those from 80 pounds in first year stubble crops and 0.70 ton in second year stubble crops. Applications of minor elements, iron, manganese, boron, zinc, and copper, did not influence yields of sugarcane in Georgia.

3. Influence of Burning Sugarcane. There was a significant drop in purity of the juice of C.P. 44-101 when the leaves were removed by burning and the cane was stored for periods up to 25 days at 75° F. During the same period, unburned samples showed an increase in purity. There was no significant change in pH or titratable acidity in the burned and unburned cane. Soluble polysaccharides increased three times faster in burned cane; this increase may be significant in the manufacturing process.

4. Photosynthesis in Sugarcane. The average rate of carbon dioxide fixation in maximum light in the field in Louisiana was between 20 and 30 mg/dm²/hr. This rate was compatible with the daily increase of sucrose under Louisiana conditions. The rates of photosynthesis of three varieties of mosaic-infected sugarcane were from 10 to 30 percent less than those of healthy cane. No significant difference in the rate of photosynthesis was found between healthy plants and plants infected with the ratoon stunting disease.
5. Stomata of Sugarcane. Differences in stomatal number and size found in species of Saccharum and varietal differences in size and number of stomata indicate a potential difference in both the rate of photosynthesis and water economy in the germ plasm of commercial hybrids. Further information is needed on this subject.
6. Cold Resistance. In Louisiana, clones of Saccharum subjected to artificial frost at 24° F. indicate a wide range in susceptibility of germ plasm. There was moderate damage to plants of S. sinense at 24° F. and comparable damage to commercial hybrids at 27° F.
7. Identification of Ratoon Stunting Disease Plants. Juice of infected plants clarified with charcoal and celite, concentrated in an ultra filter, and passed through a column of 5 percent ionagar retained infectivity based on the juvenile bud symptom expression of C.P. 44-101. Fractions of the column eluate contained virus-like particles. Further investigations are in progress to improve purification and usefulness of the procedure.
8. Flowering of Sugarcane. In Hawaii, flowering of sugarcane was delayed in 33% of the varieties tested by interrupting the night with light. Light interruption at night was most effective with S. spontaneum and S. robustum. Flowering stimuli produced through three or four inductive nights were dissipated when followed by two or three non-inductive nights. Both leaves and the spindle must be present from August 7 to 28 for floral initiation under Hawaiian conditions.
9. Storage of Pollen. Storage of sugarcane pollen following vacuum drying has not been highly successful. In Hawaii, more than 400 seedlings were produced when pollination was done with pollen stored for 17 days; these data must be checked further to verify the results.
10. Growth Inhibitors. Growth inhibitors have been identified in sugarcane stalk and root tissue. Bio-assay tests are being developed to characterize nature of the inhibitors. Research is in progress to identify and separate the phytotoxins in the inhibitors.

c. Sweet Sorghum

1. Date of Planting and Harvesting. Late plantings of the sweet sorghum variety Rio at Meridian, Mississippi, on May 15 and June 23, produced less total sugar per acre than earlier plantings. The time of harvest had no significant effect on yield of stalks, extraction, and purity; but Brix and sucrose showed a slight decline when the crop was harvested three weeks after the seed were ripe. Data from this experiment indicate that Rio can be harvested from the latter part of August until freezing temperatures in November. There was no significant inversion of sucrose in stalks of Rio when stored at above 90° F. for two days.

2. Spacing Sweet Sorghum Plants. There was no significant difference in yields of stalks and sugar per acre when sweet sorghum plants were spaced one every four inches, or three in hills 24 inches apart at Brawley, California. Yields were significantly reduced when the plant population was decreased. Lodging was not significantly influenced by the plant arrangements; however, plants spaced in bunches of three or four at 24-inch intervals were larger and less likely to lodge.

3. Maturity of Sweet Sorghum. The sugar content of sweet sorghum was still increasing 30 days past the ripe stage in an experiment at Holtsville, California. Disease infection of leaf sheaths and injured stalks two weeks after the ripe stage, may have caused some deterioration of the stalks. Further studies are needed to verify this observation.

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WEED AND NEMATODE CONTROL
Crops Research Division, ARS

Problem. Weeds cause losses in crops, orchards, grazing lands, forests, water supplies, and irrigation and drainage systems. The losses caused by weeds can be reduced by finding more effective, chemical, biological, mechanical, cultural and combination methods of weed control. Improved weed control methods will facilitate farm mechanization, greatly increase production efficiency, and improve the efficiency of the use of human and land resources in agriculture.

Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has long been known that severity of attack of certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations, cultural practices, chemicals, and biological methods on sugar crops.

USDA AND COOPERATIVE PROGRAM

Much of the weed control research in the Department is cooperative with State Experiment Stations, other Federal agencies, industry and certain private groups. The work is cross commodity in nature. The weed control program involves a total of 78.2 professional man-years. Of this total, 3.0 are specifically directed to weed control in sugar crops.

The Federal scientific effort devoted to basic and applied nematode research is 27.3 professional man-years, of which 2.3 is devoted to applied research in sugar crops at Salinas, California; Baton Rouge, Louisiana; and Logan, Utah.

PROGRAM OF STATE EXPERIMENT STATIONS

All the State Experiment Stations are conducting basic and applied research in weed control. These studies involve evaluation of selective herbicidal properties of new chemicals to show the relation between chemical structure, herbicidal activity, and weed-crop selectivity; the nature, behavior, and effect of herbicides on their degradation products in and on plants and plant products; the mechanism of herbicidal action; influence of climate, plant morphology, and soil characteristics on the effectiveness of herbicides in selectively controlling weeds and on their persistence in plant tissue. The State Experiment Stations are directing a large amount of effort toward the development of practices for the selective control of weeds in crops, pastures, and rangelands. Studies are being conducted on the movement and persistence of herbicides in various soil types and the phenomena involved in absorption and other interaction of herbicides with clay complexes.

Nematology research programs are actively pursued in 47 States and Puerto Rico. Collectively, this well-organized research program is supported not only by the institutions involved, but also by such agencies as the National Science Foundation, National Institutes of Health, private institutes, foundations, and industry. Fundamental investigations in nematology continue to receive major emphasis by State scientists.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

A. Weed Control

1. Sugar beets

In Washington, PEBC at 4 lb/A, preplant, soil-incorporated provided excellent control of barnyardgrass and fair control of lambsquarters. Incorporation 2 or 3 inches deep was superior to other depths and subsurface layering. Combinations of several herbicides were superior to single herbicides where both barnyardgrass and lambsquarters were present. In Minnesota combinations of early postemergence 3-cyclohexyl-5,6-trimethylene uracil, 5-amino-4-chloro-2-phenyl-3(2H)-pyridazinone (pyrazon), and endothall gave excellent broadleaf weed control in sugarbeets. Research to date indicated that timing is critical, and applications should be made two to three weeks after planting.

2. Sugarcane

In Louisiana, DSMA was remarkably selective when applied over the top of rhizome Johnsongrass growing in sugarcane. Top growth of Johnsongrass was killed without serious injury to sugarcane. Two applications of 4 or 6 lb/A gave approximately 72% control. Arsenic residues were not found in sugarcane juice when the last application of DSMA was made on May 11, but residues were found when the last application was made on August 26 or approximately two months before harvest. Preemergence applications of 2,3,6-trichlorophenylacetic acid at 6 or 8 lb/A in 1963 followed by retreatments at the same rates in 1964 significantly reduced yields of sugarcane on Sharkey clay but did not affect yields on Commerce silt loam. Post-emergence applications of diuron at 9 lb/A injured varieties C.P. 44-101 and C.P. 52-68 while variety N.Co. 310 was unaffected.

B. Nematode control

Although chemical agents that cause hatching of sugar beet nematode cysts have been explored for many years, no satisfactory method has been developed that will consistently cause a cyst to hatch without the presence of root exudates from a suitable host. Several organic acids were tested at Salinas, California, to determine their effect on the emergence of larvae from cysts. Only 6,9-diamino-2-ethyloxyacridine hydrochloride or

9-amino acridine hydrochloride increased larval emergence. Tests will be continued to evaluate the significance of these acids as hatching agents. There are known to be 23 plant families susceptible to the sugar-beet nematode (H. schachtii). Host studies at Salinas have shown that out of 535 plant species (283 genera) evaluated, 218 plant species from 95 genera were hosts for the sugarbeet nematode. Studies at Logan, Utah on the relationship of root shape, weight, and root-hair development of susceptible and resistant sugarbeet varieties to the sugarbeet nematode (H. schachtii) indicate that some varieties, presently listed as resistant to Heterodera schachtii, produced an excess of hair-roots; and tap roots were frequently destroyed by larval invasion even though the nematodes failed to reproduce. Sensitivity of resistant plants to larval invasion has been known for several years on tobacco root-knot-resistant variety NC-95. Preliminary investigations in cooperation with Sugarbeet Investigations at Logan, Utah indicates that the sugarbeet nematode increases the severity of root rot caused by Fusarium oxysporium.

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SUGARCANE AND SUGARBEET INSECTS

Entomology Research Division, ARS

Problem. Control of insects on sugarcane and sugarbeets is essential because of destructive plant diseases spread by insects and damage caused. The use of insecticides for insect control requires special care to avoid contamination of the harvested product with undesirable residues. Safe effective methods of control are especially needed for the sugarcane borer, the sugarbeet root maggot, and the beet webworm. Sugarcane mosaic has become more important in recent years, and information on insect vectors of this disease is needed. Beet yellows and associated western yellows virus diseases of sugarbeets continue to threaten the sugarbeet industry. Emergency chemical control measures for the aphid vectors of the viruses of these diseases are urgently needed. Studies on the ecology and methods of control of the weed reservoirs of the insects that transmit the two viruses should be continued. For long-range solutions to these problems, further investigations should be undertaken to find effective parasites and predators of sugar-crop pests and to develop varieties of sugarcane and sugarbeet that are resistant to insect attack. The usefulness of destruction of alternate host plants and new approaches to insect control, such as the male sterility technique and attractants, should be investigated. Research should aim to develop control methods without objectionable features. Key insect pests that require heavy use of insecticides for their control and thereby make the natural control of other pests on the same crops difficult are special problems that should receive emphasis in the search for nonchemical methods of control.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-range program involving basic and applied research on the insect problems of sugarcane and sugarbeet directed toward developing efficient and economical control methods. This program is cooperative with State and Federal entomologists, agronomists, and chemists in the States where research is underway and with industry. Studies on sugarcane insects are conducted at Houma, La., Canal Point, Fla., and Mayaguez, Puerto Rico; and on sugarbeet insects at Mesa, Ariz., Twin Falls, Idaho, Logan, Utah, and Yakima, Wash. A research grant has recently been negotiated with Louisiana State University to investigate the factors affecting the efficiency of Trichogramma spp. as parasites of lepidopterous pests.

The Federal scientific effort devoted to research in this area totals 8.9 professional man-years. Of this number 1.5 is devoted to basic biology, physiology, and nutrition; 2.2 to insecticidal control; 0.6 to insecticide residue determinations; 1.5 to biological control; 0.6 to insect sterility, attractants, and other new approaches to control; 0.2 to evaluation of equipment for insect detection and control; 0.6 to varietal evaluation for insect resistance; 1.1 to insect vectors of diseases; and 0.6 to program leadership.

In addition Federal support of research in this area under a grant provides for 0.3 professional man-year devoted to biological control.

In addition, natural enemies of the sugarcane borer in India are being studied under a PL 480 research grant, Project A7-ENT-1, by the Commonwealth Institute of Biological Control, Bangalore, India. Parasites and predators found effective for borer control will be made available for use in the United States.

PROGRAM OF STATE EXPERIMENT STATIONS

Research in the States on insects affecting sugar production is concerned with disease transmission, biological studies, and control.

On sugarbeets, studies are in progress on both curly top and yellows disease. Fields and desert breeding grounds are sampled to determine the population levels of insect vectors. The influence of date of planting, plant resistance, and other control practices such as foliar and seed applications of systemic insecticides are being evaluated for their effectiveness in reducing disease incidence.

The ecology of other insect pests of sugarbeets is also under investigation. Variations in temperature and other natural phenomena are being correlated with seasonal development. Records are obtained of overwintering sites, time of appearance in the spring, oviposition, pupation, emergence of late generations, host preferences, and the effects of various hosts on development.

Similar biological studies are being conducted on insect pests of sugarcane. In addition insecticides and other agents are being evaluated for their effectiveness in control. The identity and importance of natural enemies and the effects of insecticides on beneficial species is being determined. Variations in responses of plants to insect attack are also under investigation. Survey methods are being developed to obtain a more accurate estimate of losses caused by insect attack.

Scientists are investigating the possibilities of control of the sugarcane borer by radiation. Mass rearing methods are being developed and various life stages of the insect subjected to gamma radiation to determine the levels necessary for sterilization. Light of different wave lengths and chemicals are being investigated to determine their usefulness as attractants to the sterilization source.

In all, 6.3 professional man-years are dedicated to research on insects affecting sugar production in the States.

A. Basic Biology, Physiology, and Nutrition

1. Sugarbeet Insects. The spinach leaf miner caused as much as 50% defoliation in some Washington fields, yet studies indicated only 12% of the eggs resulted in mature larvae. Eggs were distributed uniformly within sugarbeet fields. In one field 99.9% of the leaves were infested with eggs on May 14. Eggs were deposited on the underside of leaves but the larval trails and blotch mines formed within the leaves were most distinct from the top side. Eggs were laid singly, in pairs, and in clusters of 5 or more. As many as 75 eggs were found on a single leaf. The trail mines of the larvae often converged but seldom was more than 1 large larva found in a blotch mine.

The relatively new ephydrid leaf miner pest, Psilopa leucostoma Meig., continued to spread through eastern Washington. It threatened to cause more damage than the spinach leaf miner by attacking the plants later in the growing season and leaving open mines subject to secondary infection by bacteria.

Winter temperature and snow cover continued to be important factors in the location and extent of overwintering of the green peach aphid and its importance in spreading yellows virus. In severe winters the aphid usually survives only in the egg stage on peaches and the spring migration to and propagation on sugarbeets is restricted to areas near orchards. In mild winters, however, the summer forms that produce only living young also survive on weeds throughout the sugarbeet area and the spring colonization on sugarbeets is usually more uniform and the spread of virus diseases much greater.

Heavy applications of nitrogen fertilizer, particularly when sidedressed on beet plants more than half grown, tended to mask typical symptoms of beet western yellows and to prevent reductions in yield.

Lygus lineolaris and related species migrated from hoary cress (Lepidium draba), tumbled mustard (Sisymbrium officinale), and other weeds to sugarbeet in June and July where several types of damage were observed. Adult feeding punctures of leaf petioles caused conspicuous galls. Punctures in the rapidly growing mid-ribs of the leaves depressed growth and caused the leaf tips to become yellow and gnarled, frequently resembling symptoms of beet western yellows. Nymphs tended to congregate in the crowns of the plants where extensive feeding caused plant sap to accumulate, ferment, and form a sticky brown deposit.

Sugarbeet root maggots collected in fields near Twin Falls, Idaho, and held in the greenhouse began maturing on May 11, 1965. Adults were observed in beet fields and also collected in bait traps on May 12. Field observations revealed the presence of maggot eggs on the crowns of young beets on May 24. Sugarbeet juice was more attractive in sticky board bait traps to the adults than young sugarbeet plants, sugarbeet roots, beet molasses, or 5%

sugar solution. Also, black was more attractive than green, white, yellow, and unpainted wood. The most flies were collected on the south side of the sticky board traps.

2. Sugarcane Insects. The annual 1964 harvesttime survey to determine degree of sugarcane borer infestation and crop loss in Louisiana showed 11% of the joints (internodes) of sugarcane bored with an estimated crop loss of 8%. The 1965 first-generation infestation in terms of borer-killed, dead-heart plants showed an estimated average of 2,743 borer-killed plants per acre. This is five times the 1964 average of 549 and 73 times higher than the 1962 average of 38. In Florida an average of 6% of the joints were bored, but in the Fellsmere area the average was 13%. In Puerto Rico infestations of the sugarcane borer remained about normal, averaging from 6 to 9% joints bored depending upon locality. The lesser cornstalk borer, fall armyworms, and the sugarcane aphid also caused damage to sugarcane in Puerto Rico. Although white grubs and wireworm infestations were of little economic importance in Louisiana, the latter caused almost complete stand failures in the sugarcane sirup area of Grand Bay, Alabama.

The white-fringed beetle caused considerable damage to sugarcane in the sirup area near Mobile, Alabama. The stand and growth of the plants were impaired by the larvae injuring the underground portions of the stubble and roots during the early growing season. As many as 9 larvae were found infesting the new growth in one 6-square-inch sample of sugarcane stubble.

The southwestern corn borer, reported to be a pest of sugarcane in some areas of Mexico, was found near sugarcane fields in Louisiana, but none was found in the fields examined.

A new antibiotic system based on Tegosept and Hyamine 1622 (Di-isobutyl phenexy ethoxy ethyl dimethyl benzyl ammonium chloride, monohydrate) has been successful in eliminating contamination in semi-artificial sugarcane borer diet. Tegosept at 1.5 grams and Hyamine 1622 at 3.0 grams are blended with 500 grams of sugarcane tops and joints, 50 grams of a high protein base, 10 grams of ascorbic acid, and 750 mililiters of water. After blending to a coarse consistency, excess liquid is pressed out with a potato ricer, leaving sufficient residual antibiotic to control fungi completely. With this diet large numbers of sugarcane borers can be reared for laboratory testing.

B. Insecticidal and Cultural Control:

1. Sugarbeet Insects. One pound of phorate, applied as 10 pounds of 10% Thimet granules, per acre with aircraft in Washington to sugarbeets infested with the two-spotted spider mite, gave 97% control for 29 days and 93% control for 49 days. A 10% granular Di-Syston formulation applied in the same manner was not effective.

The seasonal control of the green peach aphid on sugarbeets increased as the number of applications of demeton, dimethoate, phosphamidon, and Meta-Systox sprays applied with aircraft increased from 2 to 6. The spread of beet western yellows virus, carried by this insect, also declined as aphid control increased. Demeton and Meta-Systox gave best control. All treatments increased yields, and in 1 field 6 tons more beets were harvested from the demeton plots than from the check plots.

Yield records obtained from 50 Walla Walla, Wash., beet growers in the fall of 1964 showed that 30 growers who made 1 application of 10% Di-Syston granules at 10 lb/acre in May to prevent the green peach aphid from spreading beet western yellows harvested an average of 17.6 tons of beets per acre, or 15% more than growers who did not apply insecticides.

Satisfactory control of the spinach leaf miner was obtained with single applications of sprays containing one-half pound of Dylox or Meta-Systox, or one pound of Phosphamidon or Di-Syston in 30 gallons of spray per acre with a row-crop sprayer. Larvae were found more susceptible than eggs to the treatments. Preliminary observations indicated that 10 pounds of 10% Di-Syston granules at 10 pounds per acre dribbled on the infested beets was less effective than Di-Syston spray.

Laboratory and greenhouse screening tests at Twin Falls, Idaho, on 55 candidate insecticides for slurry seed treatments to control the beet leafhopper showed only 12 worthy of field tests. In subsequent field tests only phorate reduced leafhopper spread of curly top as much as 40%.

In an experimental field planting of pelleted sugarbeet seed by the Logan, Utah, station, dimethoate at 8 ounces or phorate at 3 ounces per acre reduced the beet leafhopper population 84% on plants in the 8- to 12-leaf stage of development. The seeds were first coated with blood-protein complex to prevent phytotoxicity before being pelleted. In greenhouse tests dimethoate added to pelleted sugarbeet seed at 7 ounces per acre gave 100% mortality of beet leafhoppers caged on plants in the 2-leaf stage.

Of 33 materials screened in the laboratory at Twin Falls, Idaho, 17 were as toxic to beet webworm as DDT and trichlorfon used as standards, but all except Kepone are experimental materials as yet not available to growers.

Sugarbeet yields were not increased by use of insecticides for the control of the sugarbeet root maggot at Twin Falls, Idaho, even though the population of this insect was decreased by some materials. Sixteen insecticides were applied as granular formulations in the drill row at planting time or incorporated into the seedcoat of pelletized seed. Considering both the maggot count and yield, ethion, carbophenothion, schradan, stabilized phorate, V-C 13, and Stauffer 2790 showed enough promise to justify further testing.

In root maggot and symphylan experiments in Utah, pelleted sugarbeet seed containing dimethoate at 3 ounces per acre improved the emerged stand of unthinned beets 12% and increased the yield 0.8 ton per acre in one field and 4.4 tons in another. Seed coated with blood-protein complex to prevent phytotoxicity and pelleted with phorate at the rate of 3 ounces per acre increased the emerged stand by 30% and the thinned stand 12% over the untreated checks. This treatment increased the yield of sugarbeets 0.7 ton per acre. Di-Syston added to the pelleted seed at 1.5 ounces per acre reduced symphyllans 43%, increased the stand of plants 29%, and increased the yield of beets 3.1 tons per acre. In other tests, however, at double the dosage of Di-Syston the stand of plants was reduced.

Lygus bug damage to sugarbeets grown for seed in Utah was controlled by dimethoate spray applied when the plants were in the prebud and flowerbud stage of growth. The viability of the harvested seed was 94% in the sprayed plots as compared to 88% in unsprayed check plots. The emulsion contained 10% of molasses. Dimethoate without molasses was less effective. Naled emulsion also was less effective.

2. Sugarcane Insects. Endrin has been recommended for control of the sugarcane borer in Louisiana since 1958. In 1962 it became apparent that borer resistance to endrin had developed at several locations. This insecticide gave an average control of only 51% in three widely separated locations in 1964. Since 1962 an effort has been made to find new insecticides to control the borer. Large-plot aerial tests with endrin, Guthion, methyl-ethyl Guthion, carbaryl, endosulfan, diazinon, and parathion all applied in a granular form were conducted in 1964. Guthion gave the best control. Control with both endrin and endosulfan, which formerly gave good control, was relatively poor, indicating that sugarcane borers are resistant to these insecticides. Diazinon gave fair control but was toxic to predaceous and saprophytic arthropods.

In Florida on muck soil infested with wireworms, treatments with phorate at 2 pounds per acre, heptachlor at 4 pounds, and Telodrin at 2 pounds per acre all gave increase in yield of sugarcane of more than 5 tons per acre.

During recent years in Louisiana, chlordane has been widely used in sugarcane fields for control of wireworms and small soil arthropods. Since there is a possibility that repeated applications of the insecticide might create a phytotoxic condition in the soil, a large-plot experiment to study this possibility was initiated in 1958. Seven alternate cuts planted in sugarcane variety N.Co. 310 were treated that year and again in the fall of 1963 when the experimental area was replanted with variety C.P. 44-101. Yield data obtained for three crops following the first chlordane application revealed no phytotoxic effects. None of the differences for any of the three years were statistically significant.

Chlordane applied to seed pieces at planting time in wireworm and white-fringed beetle infested fields increased sugarcane stands. At Grand Bay,

Alabama, chlordane at 3 lb/acre applied in a 25 acre field planted with sugarcane varieties C.P.'s 29-116 and 36-111 in late September increased stands by 25%.

C. Insecticide Residue Determinations

1. Sugarbeet Insects. Objectionable drift of insecticides were observed when experimental applications of sprays and granules drifted from the target areas in Washington. In one instance, 50 ppm residue of an organic phosphate insecticide was found on alfalfa 50 feet inside a field several days after an adjoining beet field had been sprayed. In this case the residue resulted from spray that was carried off target in the slipstream of the aircraft as it pulled up out of the beet field. In another case, 2 ppm residue was found on alfalfa 75 feet and 0.1 ppm as far as 340 feet from the edge of a beet field following an aircraft application made with a cross-wind in excess of 5 mph. In the third case, granules of an organic phosphorus insecticide applied by aircraft with a cross-wind of 3 mph drifted 179 feet from a beet field.

Demeton residues on filter-paper squares placed in a plot of sugarbeets receiving 5 aircraft applications of demeton at 1 pound in 9 gallons of spray per acre showed that approximately 25% of the demeton impacted within the plot. Demeton recovery across the plot ranged from 0 to 0.82 ppm in samples taken immediately after the last application. The average demeton residue found on the leaf surfaces was 33 to 53% lower than that found in the filter papers put in the field before spraying. The average deposit on the foliage ranged from 6.0 to 7.3 micrograms of demeton per square inch and that on comparable filter paper from 9.9 to 12.7 micrograms per square inch.

Six aircraft applications at 2-week intervals of demeton, Meta-Systox, and phosphamidon at 1 pound active material in 9 gallons of spray per acre left no objectionable residues in the leaves 43 days after the last application.

Di-Syston or phorate granules (10%) were applied to sugarbeet plots by fixed wing aircraft at the rate of 1 pound of actual insecticide per acre. Samples of foliage, crowns, and roots harvested 51 days after application showed Di-Syston residues of 0.08 and 2.99 ppm on the foliage, 0.08 and 6.27 ppm on the crowns, and 0.09 and 0.08 ppm in the roots. Samples from the phorate plots showed residues of 0.35 and 0.57 ppm in the foliage, 2.60 and 1.68 ppm in the crowns, and less than 0.04 ppm in the roots.

In studies of organic phosphates at Yakima, Wash., no measurable residues were detected in roots or crowns of sugarbeet plants 116 days after an application of Bayer 39007 granules at 2.5 lb/acre in an 8-inch band on top of the plants, or 97 days after a similar application of phorate, or a 1-2-2 mixture of dimethoate, phorate, and schradan. The Bayer 39007 left a residue of 0.05 ppm on the foliage. The phorate treatment left no residue on the foliage. The mixture left a foliage residue of 0.16 ppm

calculated as schradan and attributed to schradan. In similar studies with sprays applied to the foliage 97 days before harvest, demeton or phorate at 1.2 lb/acre left no residues on the leaves, crowns, or foliage. A spray mixture of equal parts demeton and schradan left 0.17 ppm on the foliage. A spray mixture of equal parts of phorate and schradan left 0.16 ppm on the foliage calculated as schradan and attributed to schradan.

D. Biological Control

1. Sugarcane Insects. Investigations directed toward finding new and effective parasite species against the sugarcane borer were continued. Ten species that attack sugarcane borers in India were obtained through PL 480, A7-ENT-1 for study in the laboratory at Canal Point, Florida. Three of these, Apanteles flavipes, Stenobracon deesae, and S. nicevellei displayed sufficient potential to justify rearing and releasing in commercial fields.

Observations were continued in southern Florida to ascertain more precisely the role and importance of the presently existing biological entities toward reducing the sugarcane borer population. Agathis stigmatera Cress. parasitized an average of 15.9% of the borer population during 1964. Late instar larvae and pupae mortality averaged 22% as a result of earwig (Dermaptera) predatism during the months of August through October, 1964. Trichogramma fasciatum Perkins egg parasitism during the late summer and early fall ranged as high as 96% in some parts of the Everglades.

Fall parasitization of sugarcane borer by the Cuban fly, Lixophaga diatraeae, was as high as 40% in one field on a plantation in Louisiana where the last releases were made in 1956. This tropical parasite has survived two of the recent coldest winters of this century and also the commercial application of insecticides for borer control in Louisiana.

Studies in Puerto Rico indicate that Cuban fly parasitization is apparently density-dependent. When sugarcane borer population density is high, all life stages of adequate size are parasitized at an almost equal rate. This contrasts with parasitization of approximately double the number of third and fourth instar larvae compared with fifth and sixth instar when parasite population densities are low. In Puerto Rico, high parasite population densities seldom appear because of an apparently excellent balance between parasite and host. When environmental conditions are such that borer numbers are encouraged or parasite numbers are reduced, a population explosion of borers occurs with consequent upswing of parasitization rate until normal balance are reestablished.

Stenocranophilus quadratus and Anagrus armatus, two parasites introduced into southern Florida in 1959 from Jamaica, are currently holding the population of the West Indian sugarcane delphacid at a low level.

S. quadratus, now found throughout the Florida sugarcane area, was found parasitizing an average of 36% of the pests in 68 of 72 fields sampled during December-January, 1964-65. A. armatus was recovered in fields over 40 miles from the 1959 release site and was found in 48 of 97 fields examined.

E. Insect Sterility, Attractants, and Other New Approaches to Control

1. Sugarcane Borer. In Puerto Rico aziridine and uracil compounds which are effective chemosterilants for some insects caused high mortality when tested against sugarcane borer moths.

Sex attractant studies have suggested that the sugarcane borer female pheromone is not a primary long-range attracting stimulus but is probably essential for copulation initiation and possibly as a means of close-range male orientation with females. Darkness alone stimulates general male activity. Extirpation of the antennal flagellum of males precludes mating but does not interfere with general activity in darkness. In the laboratory continuous light was found to completely suppress mating activity of the sugarcane borer, even when the favorable two male for one female sex ratio was used. Further studies exploiting this new approach to insect control have shown that intermittent applications of light, 10 seconds per five minutes, suppresses almost all mating activity. High intensity flash treatments at 10 second intervals for five minutes also disrupt mating activity. However, a normal sugarcane borer infestation developed in lighted field plots which were many times lighter than the amount of darkness required for mating.

F. Varietal Evaluation for Insect Control

1. Sugarbeet Insects. No preference was shown by the green peach aphid for any of 25 varieties and selections of sugarbeet tested in Washington.

2. Sugarcane Insects. Of 281 sugarcane varieties tested in hand-infested plots in Louisiana, 41% had a lower percentage of joints bored, and 46% produced more sugar per acre than standard variety C.P. 36-105. Thirty-seven varieties of sugarcane consisting of one control variety, one new commercial variety, and 34 unreleased varieties were field-tested under two levels of borer infestation in 1964 to obtain information on their relative tolerance. Varieties C.P. 61-90, C.P. 58-48, L. 61-40, L. 61-41, and C.P. 61-43 showed a loss of less than 13 pounds of sugar per acre for each 1% joints bored. The greatest losses, ranging from 61 to 75 pounds for each 1% joints bored, were shown by varieties L. 61-52, L. 60-25, L. 61-9, L. 60-12, and C.P. 36-105.

H. Insect Vectors of Diseases

1. Sugarbeet Insects. In the Salt River Valley of Arizona, plots of sugarbeets grown for seed under conditions of high, intermediate, and low fertility were infested with virus yellows infective green peach aphids and seed yields compared to similar plots maintained aphid-free. Plots were arranged in a 6x6 latin square. The level of nitrogen fertilizer in those plots designated as "Intermediate" was similar to that used by the average beet seed grower. The nitrogen level of the "High" plots was approximately double that of the "Intermediate" plots, while the "Low" plots received less than half of the total nitrogen of the "Intermediate" plots. Results showed that under virus yellows-free conditions the fertilizer program of the average beet seed grower in the Salt River Valley is adequate and nothing is gained by additional applications of nitrogen fertilizer. However, if the crop is likely to be subjected to heavy infestations of virus yellows infective aphids, part of this loss can be averted by additional applications of nitrogen fertilizers.

In Washington losses in yields in sugarbeet plants that were tagged in a sugarbeet field and naturally infected with yellows viruses were 46% on early-infected plants and 33% on late-infected plants. Similar losses were obtained when caged plants were infested by hand with viruliferous aphids for 1 week and the aphids killed. The yield of beets infested May 5, May 22, and June 12 was reduced 46%, 37%, and 25%, respectively.

Greenhouse tests at Yakima, Wash., showed that at least 28 local species of wild and cultivated plants belonging to 7 different families served as alternate hosts of beet western yellows. Most important of these were several perennial, biennial, or fall-sprouting annuals in which the disease can overwinter in the field. Infected beets, which can survive most winters in the Pacific Northwest, were found capable of overwintering beet yellows, as well as beet western yellows and beet mosaic.

Yield data obtained from growers who continuously grew beets for several consecutive years showed that after the second year yields declined sharply. Part of this reduction, at least, was caused by a gradual increase in yellows in alternate host plants near these fields facilitating spread by the green peach aphid.

Although larger populations of the green peach aphid developed on sugarbeets in fields near peach orchards than elsewhere, the incidence of beet western yellows carried by this insect was greater in fields near deep, drain ditches and other ecological niches in which the summer forms of the aphid and virus-infected alternate host plants overwintered successfully.

Summer forms of the green peach aphid overwintered successfully on hoary cress (Lepidium draba), sowthistle (Sonchus sp.), curly dock (Rumex crispus) in protected locations of eastern Washington during the mild winter of 1963-64 and also apparently on spinach and shepherds-purse (Capsella Bursa-pastoris) in

unprotected places. However, during the cold winter of 1964-65 they also overwintered on hedge glorybind (Convolvulus sepium) in protected locations. Irrigation drains were particularly favorable locations for overwintering of the aphids.

2. Sugarcane Insects. Mosaic disease continues to be a problem of great economic importance in sugarcane production in Louisiana. Since the disease is spread by insects, it seems logical that an appreciable reduction in mosaic spread could be attained if the vector population could be effectively controlled. In a 22.62-acre plant cane block of two disease-susceptible varieties, C.P.44-101 and C.P.52-68, treated with demeton in the fall and spring, percentages of mosaic reduction in June were 30 in the latter and 64 in the former variety. Control of vectors ranged from 82 to 100%. Malathion + heptachlor, Di-Syston, dimethoate, phorate, demeton, and diazinon were evaluated as disease-vector controls. All chemicals gave a 100% control of the rusty plum aphid (Hysteroneura setariae), the only species recorded for which sugarcane is a natural host. Dimethoate and phorate reduced mosaic spread by 20% each, and malathion plus heptachlor and diazinon showed reductions of 25 and 38%, respectively. None of the materials showed any phytotoxic effects.

Although sugarcane is not a natural host for the corn leaf aphid, studies showed that the insect can be cultured on sugarcane plants. Sugarcane mosaic transmission tests with the bean and cowpea (Aphis craccivora) and the southern corn rootworm (Diabrotica undecimpunctata howardi), 2 insects prevalent in sugarcane fields, gave negative results.

Vector-virus relationship transmission studies in cooperation with pathologists with the corn leaf aphid showed that (1) the insect became viruliferous within 5 minutes after being placed on mosaic-infected sugarcane plants, (2) viruliferous insects transmitted mosaic within 15 minutes after being placed on healthy sugarcane plant, (3) the insect apparently lost the ability to transmit mosaic within 1 hour after being removed from diseased plants, and (4) there was a difference in mosaic transmission between insects cultured through several generations on mosaic-infected sorghum and those cultured on mosaic-infected sugarcane plants for 24 hours prior to being transferred to healthy test plants. Similar studies with the brick-red sowthistle aphid indicated that this aphid (1) also became viruliferous within 5 minutes after being placed on mosaic-infected sugarcane plants, (2) transmitted the virus within 5 minutes after being placed on healthy plants, (3) remains viruliferous for only a short time, (4) can transmit the virus to more than one plant, and (5) loses ability to transmit mosaic after feeding on healthy plants for $1\frac{1}{2}$ hours. These studies show that the sugarcane mosaic virus is non-persistent; it does not require a latent period before being transmitted, and the vector remains infective for only a short period.

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CROP HARVESTING AND HANDLING OPERATIONS AND EQUIPMENT
Agricultural Engineering Research Division, ARS

Problem. This area is concerned with the development of equipment and methods for efficiently harvesting and farm handling crops, with emphasis on the preservation of inherent qualities during these processes. The cost of harvesting and farm handling of most crops is the major expense of production, often amounting to over half of the total returns to the producer from the sale of the product. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory.

USDA AND COOPERATIVE PROGRAM

Equipment and methods for harvesting sugarcane are under study at Houma, Louisiana, in cooperation with the American Sugar Cane League; and in Belle Glade, Florida, in cooperation with the Florida Experiment Station.

A contract with the University of Sao Paulo, Brazil, on mechanization of sugarcane production has been terminated due to lack of funds and personnel.

A 3-year contract was initiated at Louisiana State University for research on mechanically removing tops and leaf trash from sugarcane.

The Federal engineering effort of 1.0 professional man-year is devoted to research on sugarcane.

PROGRAM OF STATE EXPERIMENT STATIONS

Most of the state agricultural experiment stations are engaged in some aspect of basic or applied research which is concerned with improving machines and methods for efficient harvesting and farm handling of the many economic crops which make up the total national agricultural production. Much of this research effort is cooperative with the Department.

Current research is concerned with the diverse problems involved with these specific crops: All small grains, including rice and field corn; cotton, peanuts, castor beans, and safflower; citrus, apples, peaches, olives, apricots, cherries, prunes, cranberries, coffee, grapes and pecans, green-cut forages, hay and seed crops; cabbage, lettuce, asparagus, tomatoes, Irish potatoes, sweet potatoes; blueberries, peas and sweet corn; tobacco; and sugarcane.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

Sugarcane Harvesting Equipment

1. Harvesting hurricane-damaged sugarcane in Louisiana. Harvesting efficiency and trash determinations were made on the USDA cutter-cleaner-loader during the latter part of October, which was approximately 4 weeks after a severe hurricane. Harvesting in the direction that sugarcane leaned was more effective when compared to the effectiveness of conventional machines. Harvesting efficiency averaged 83.5 percent in variety C.P. 52-58. The machine uprooted considerable amounts of stubble when operating against the direction of sugarcane lean and averaged 68 percent harvesting efficiency. (The normal efficiency when operating in upright cane with the USDA machine is 95 percent.) Many conventional harvesters were placing less than 50 percent of the cane in a heap row. Consequently, hand scrapping was necessary and found to be expensive.
2. Mechanically removing tops and leaf trash from sugarcane. A major problem of harvesting recumbent sugarcane is to remove and separate the leaves and tops from the cane stalks. This investigation was initiated in June 1964 with the Louisiana State University, Agricultural Engineering Department under a 3-year research contract. A comprehensive search and review of literature on methods for removing extraneous material from the cane was made and a report prepared. Laboratory equipment was developed and tests initiated to determine the effectiveness in removing leaves when subjecting sugarcane plants to high temperature flame and an air blast. Equipment and instruments for more detailed study are being obtained. This work is cooperative with the Louisiana State University Agricultural Engineering Department and the Audubon Sugar Factory.
3. Harvesting recumbent-type sugarcane. Methods of gathering, orienting and cutting recumbent cane are being studied in order to harvest cane without damaging the stubble. This is a new line project, and the work is being conducted at the Everglades Experiment Station, Belle Glade, Florida, in cooperation with local sugar producers and mills. An observational study of two experimental harvesters has been made; one harvester using a 36-inch diameter ground knife and chain pickup, the other using two 12-inch diameter ground knives with a spiral-auger pickup. These have operated on two soil types both under wet and dry conditions. High speed photography will be used in studying the stubble and ground reaction with these two machines.
4. Mechanization of sugarcane production in Brazil. Two experiments are underway at the University of Sao Paulo, Brazil, under research contract using PL 480 funds. This work is concerned with minimum tillage in sugarcane and with the development of a mechanical harvester.

When two varieties were planted on unplowed pasture and compared with conventional seedbed preparation, the following conclusions were made: (1) Germination is not affected; (2) tillering (underground branching) was better in plowed plots; (3) there was no difference in soil moisture during drought-stress periods; and (4) weed population was the same.

A prototype stripping unit using cylinders with three-eighths-inch diameter wire rope was side-mounted on a tractor to strip a row of standing cane. The cane had been previously topped by hand. A rotor speed of 650 r.p.m. with a forward tractor speed of 1.8 m.p.h. gave best results. A reasonable stripping job was obtained although no trash measurements were made. The wire rope damaged the cane and was broken at the point of attachment.

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

None.

II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

SUGARCANE - PROCESSING AND PRODUCTS

Northern Utilization Research and Development Division, ARS
Southern Utilization Research and Development Division, ARS

Problem. Quotas established by the Sugar Act effectively prevent the accumulation of surpluses by limiting production to estimated requirements at stable, low prices for sugar. Prices received by farmers of the United States and Puerto Rico for sugarcane are based upon the recoverable sugar content of the cane; and the rising costs of production and processing make imperative the more efficient recovery of increased amounts of sugar to provide adequate returns for both processors and growers. Currently, recovery of 75 percent of the total sugar in the cane is considered satisfactory in Louisiana, and about 83 percent in Puerto Rico and Hawaii. Improved processing methods could increase the recoverable sugar to at least 85 percent in Louisiana and over 90 percent in other areas. The development of more efficient processing methods depends in turn upon the acquisition of adequate data on the quantitative composition of juices extracted from sugarcane, and of materials processed to recover sugar. The chemical industry provides a promising potential for the utilization of additional sugar since more than 15 billion pounds of chemical products are produced annually and sold to every section of American industry. More information is needed on the chemistry and properties of products from sugar to expand their utilization and on the application of these derivatives in the production of plastics, protective coatings, emulsifiers, detergents, and the like.

USDA AND COOPERATIVE PROGRAMS

The major part of the Department's research program on sugarcane processing and products is maintained at the Southern Utilization Research and Development Division, New Orleans, Louisiana. At the Northern Division, Peoria, Illinois, the Department has maintained a long-term continuing program involving microbiologists and biochemists engaged in basic and applied research on the fermentative conversion of sugar to industrially useful organic acids. Since the objectives have been achieved, this program was terminated with completion of the current project. No further studies are planned.

The Federal program at Peoria, Illinois, totals .6 professional man-year, all of which is devoted to new and improved products, specifically, fermentative conversion of sugar to α -ketoglutaric and 2-ketogluconic acids. This research has been completed.

In addition, the Department, through the Northern Division, sponsors research in this area under a grant of PL 480 funds to the Institute of Biological Chemistry, University of Rome, Rome, Italy, for studies on the preparation and characterization of dextran derivatives (5 years, 1961-1966). This research is under the subheading, new and improved products.

At the Southern Division research on chemical composition and properties is being carried out under a grant of P.L. 480 funds to Kyoto University, Kyoto, Japan, for isolation and identification of the nucleic acid derivatives of cane molasses, in order to obtain information applicable to expanding the utilization of molasses industrially and in feeds (project duration - 2 years).

The Federal in-house scientific research effort in this area has been terminated. P.L. 480 research involves 1 grant for research on chemical composition and physical properties.

The following line of work was terminated during the year: (1) Investigation of extractable complex polysaccharides of sugarcane in relation to efficiency of recovery and purification of sugar. (2) Pilot plant development of improved methods of purification of juices and sirups to increase sugar recovery and reduce costs of processing sugarcane. (3) Chemical and physical investigations of sugar refining operations to improve processing of cane sugar.

PROGRAM OF STATE EXPERIMENT STATIONS

Station sugarcane utilization research begins with studies directed to obtaining new, early maturing or cold-tolerant varieties which have a high yield and are adaptable to standard milling procedures and extends to work directed to preparation of flavored sirups for food use.

Most of the basic and exploratory research is carried out at the Puerto Rico station. Use of ion-exchange procedures for the production of sugars that may be utilized without further purification is under continuing study. Other work in progress involves: development of pilot-plant fermentation procedures for fermenting molasses mashes to produce rum; development of distillation procedures for high efficiency rum distillation; search for new strains of yeast for use in fermentation of blackstrap molasses and other materials derived from sugarcane; and determination of factors affecting the sucrose content of cane.

The study which was carried out in cooperation with USDA and which pertained to utilization of sorgo juice for sirup and sugar production is being terminated.

Indiana station research seeks to synthesize analogues of important metabolic sugars wherein hetero atoms such as sulfur, selenium or nitrogen replace the normal oxygen atom. Sugar analogues and their derivatives will be tested for usefulness as medicines or as agricultural chemicals.

The research effort on utilization of sugarcane is 4.9 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Basic Studies of the Chemical Composition and Physical Properties of Sugarcane Juice and Its Products. Knowledge of the composition of the characteristic soluble polysaccharide constituents ("gums") of sugarcane may provide a basis for developing methods to determine the concentrations present in juices, sirups, and raw sugars.

Experiments have continued on freshly harvested, hand-cleaned cane from which levorotatory polysaccharide was previously isolated. Crusher juice expressed without addition of water, and maceration juice obtained from the residue by further extraction with water in two successive crushings, were treated separately with alcohol to precipitate the crude gums. These preparations yielded 8 g. having a specific rotation of -42° , and 13 g. having a specific rotation of -44° , respectively, of the levorotatory polysaccharide, essentially identical with that obtained previously from crusher juice only, which had a specific rotation of -43° . Analyses showed that this polysaccharide was composed of high percentages of pentoses and relatively little glucose, a distribution which indicates that the material is virtually free of contamination by adventitious dextrans. This reproducibility of the isolation of the levorotatory polysaccharide from uncontaminated cane establishes its importance as a natural constituent of juices. Optimum conditions for complete hydrolysis of the polysaccharides and minimum destruction of sugar are 20 to 25 minutes in 4N hydrochloric acid at 100° C. Analyses of the hydrolyzed polysaccharide showed the following composition: glucose, 2.73%; fructose, 1.3%; galactose, 15.4%; rhamnose, 3.0%; arabinose, 30.0%; and xylose, about one-half the concentration of arabinose. The galactose and rhamnose content of molasses polysaccharide, which is contaminated with dextran, is much lower than that of fresh juice polysaccharide. This relationship suggests that the amount of natural polysaccharide in the total nondialyzable polysaccharides could be estimated by determination of the galactose in the hydrolyzed total polysaccharide.

The phenol-sulfuric acid method, which gives higher color yields than anthrone for colorimetric determination of pentoses, was used to analyze the purified gums. The procedure requiring dialysis of samples for determination of total gums was too cumbersome for routine use, and a simpler method was devised for application in factory control laboratories and in cooperative work with the Crops Research Division at Houma.

Analyses of amylose-amylopectin ratios and starch content of juice samples collected during the 1964 season have been completed. The data indicate that sugarcane starch composition (amylose/amylopectin) is affected by the plant's growth rate and variety. Therefore, the method employed for analysis of total starch should be one that gives quantitative results which are independent of variations in starch composition. (S5 1-81).

In a two-year project being conducted at Kyoto University in Japan under a P. L. 480 grant now nearing termination, an investigation is underway to isolate and identify the nucleic acid derivatives that occur in sugarcane molasses. Thin-layer chromatography, ion exchange chromatography, and continuous liquid-liquid extraction are being used to isolate the nucleic acid derivatives. The separation of bases and nucleosides, an important biochemical problem, was attempted by gas-liquid chromatography, but so far has been unsuccessful. However, a technique involving trimethylsilylation was found to afford easily distillable derivatives. By this technique followed by quantitative hydrolysis with aqueous alcohols, 18 bases and nucleosides were separated and identified. In the course of the work, a new component was found and its presence confirmed. The structure of this component is being investigated. The basic information obtained in the project is expected to be useful in assessing the role of minor non-sugar components in sugarcane processing and in the use of cane molasses for feed and industrial applications. (UR-A11-(50)-7).

2. Investigations of the Fundamental Chemistry and Physics of Sugar Refining. In cooperation with the Cane Sugar Refining Research Project, Incorporated, an association of commercial sugar refiners, basic investigations of the chemistry and physics of sugar refining were conducted to improve processing of sugar. The molecular weights of gums isolated from juices and molasses were found to be larger than the maximum value, about 500,000, amenable to determination by osmometry; this result agrees with the previous estimate from light scattering measurements that the weight-average molecular weights range from 700,000 to 3,000,000.

The reducing sugars in molasses, long regarded as a simple glucose-fructose mixture termed "invert," have been shown to consist of more complex mixtures, including mannose and psicose. It is imperative to know the quantitative composition of this major portion of molasses solids, since it affects the amount of sugar that can be crystallized. Reproducible estimates of the amounts of glucose, fructose, and mannose in the reducing fractions were obtained for samples of refinery and raw factory molasses. Total reducing sugars ranged from 9.2 percent in one refinery sample to 22.1 percent in one factory sample; mannose ranged from 0.14 to 3.13 percent of the weight of the molasses. Glucose ranged from 37.7 to 50.6 percent of total reducing sugars. There was wide variation in the individual sugars and total reducing sugars expressed as percentage of the total molasses and of individual sugars expressed as percentage of total reducing sugars. Analysis of an additional refinery molasses sample provided evidence of a nonreducing, levorotatory constituent other than the known sugars in the fraction separated by chromatography on carbon columns.

The chemistry of the precipitation of basic calcium phosphates in water and in aqueous sugar solutions was also investigated. An understanding of the precipitation of this material is essential, for it is used in clarification, the least understood step of the refining process. By crystallography of the basic calcium phosphates in clarifier scums, the principal precipitate was identified as octacalcium phosphate, though anhydrous dicalcium phosphate and hydroxyapatite are also present. The effect of various solution parameters and foreign ions on the crystal habits of the basic calcium phosphates was studied by means of the petrographic microscope.

In an attempt to separate sugar colorants, high voltage paper electrophoresis was not successful in separating the colors of molasses. About ten fractions that were not always sharp have been demonstrated by fluorescence and various reagent sprays. However, the color remains spread over the entire region with little separation. (S5 1-77).

B. New and Improved Processing Technology

1. Processing Procedures to Improve the Refining Quality of Raw Sugar. As selectively bred canes produce higher yields, removal of tops and trash by present harvesting machines becomes less effective. The effect of additional impurities introduced into the juice by grinding this material was investigated in cooperation with the American Sugar Cane League to anticipate problems in clarification and provide a basis for attempting to modify the process to overcome these problems. Pilot-plant clarification tests of topped and new canes from the 1964 crop were completed essentially as planned. To determine the effect of cane tops on clarification, control canes were cut by hand at the top and bottom without the leaves being stripped from the stalk, whereas test canes were harvested in the same manner except that the tops were left on 50% of the stalks to simulate cane harvested mechanically from badly lodged fields. Trash content on stubble cane harvested early in the season averaged 10% and 3%, respectively, on test and control canes. In comparison with the controls, test canes had twice the amount of soil in juice, required 30 percent more lime, and produced 15 percent more clarifier mud; their clarified juice was 20 percent lower in clarity, 3.5 points lower in purity, 20 percent higher in CaO , and 35 percent higher in P_2O_5 .

New canes evaluated were: 1) the most recently released commercial cane, C.P. 55-30; 2) the new standard commercial variety, C.P. 52-68; and 3) one unreleased variety, L. 60-1, the latter of which was harvested by machine and burned during adverse weather and hence is not directly comparable to the first two samples. Operations and average clarifier juice quality factors for the two commercial varieties were essentially identical, except that C.P. 55-30 produced less clarifier mud. The results on pot-liming, limited to a few tests, were not encouraging, since it requires additional clarifier capacity.

Methods developed in the pilot plant to improve the refining quality of raw sugar offer potentially valuable information to processors and refiners. The largest sugar refinery in the area was assisted in evaluating the rapid Millipore membrane-type test to determine the filterability of melted raws. One of the refinery filters is being operated under controlled conditions to correlate data from this test with operating data. If the test proves reliable, this independent evaluation by a refiner should expedite its acceptance by industry.

In addition, the need for better harvesting machines to remove higher percentages of cane tops and trash was well demonstrated and should stimulate efforts to develop improved equipment. (S5 1-80).

C. New and Improved Products

1. Fermentative production of α -ketoglutaric and 2-ketogluconic acids. Experiments indicated that the Krebs cycle was responsible for formation of α -ketoglutaric acid by Pseudomonas sp. Therefore, experimental yields obtained under the best conditions are, in fact, close to the theoretical maximum of 54 percent. Further work on production of this acid is not desirable, since this yield would be too low to interest industry.

On the other hand, the process for 2-ketogluconic acid, developed collaterally in the course of this project, continues to appear very promising for industrial adoption. Crystalline calcium 2-ketogluconate was isolated from runs in 20-liter fermentors in a yield of 63 percent and in near 100-percent purity.

All studies specified in this project have now been completed. No further research on fermentative conversion of sugar to industrially useful products is planned.

2. Studies on dextran derivatives. Progress has been made on study of the kinetics and mechanism of reaction of (a) the controlled depolymerization of dextran by Fenton's reagent and (b) the interaction of dextran with gamma-globulin. Kinetics of reaction have been established for systems involving dextran derivatives with the model protein lysozyme, with certain dyes, and with metal salts that form complexes. Ultracentrifugation and electrophoretic examination indicated that phosphomannan Y-2448 has very narrow size distribution and therefore is a most exceptional polysaccharide. This research is being conducted under a PL 480 grant by the Institute of Biological Chemistry, University of Rome, Rome, Italy. In view of the termination of research on cane sugar at the Northern Division, further progress on this PL 480 project will be reported in Area 5, Wheat and Corn, Fermentative Conversion to New Industrial Feed and Food Products.

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* Research supported by PL 480 funds.

SUGAR BEETS - PROCESSING AND PRODUCTS
Western Utilization Research and Development Division, ARS

Problem. Sugar beets are mainly processed for sugar; a very small proportion is used for livestock feed. Sugar beets are declining in sugar content and rising in impurities. The traditional processing methods for sugar manufacture cannot cope efficiently with beets whose lower quality is due in part to excess nitrogen fertilizer, used to improve tonnage yields. Improved processing procedures should benefit both the growers and processors. It is known that small concentrations of certain chemicals in beets affect processing quality but not enough information is yet available to devise new economical procedures for high-impurity beets. Because costs of producing beets and processing sugar are rising whereas per capita consumption and price of sugar are essentially constant, all factors important to utilizing the crop must be examined to improve processing. There is still much to be learned about the composition of sugar beets, juices, pulp, and crude sugar. Sugar losses resulting from spoilage and respiration of beets held at processing plants cannot be prevented by existing methods.

USDA AND COOPERATIVE PROGRAM

Utilization Research on this Area has been discontinued. Research grants under P.L. 480 continue on basic research at Jerusalem, Israel and on product developments at Calcutta, India.

PROGRAM OF STATE EXPERIMENT STATIONS

The station program on sugar beet utilization is concerned with chemical composition of the beets. The effects of management, genetics, and environmental factors on yield and quality of sugar beets, including sucrose content of root and purity of juice is being determined. Other research, while serving projects designed to consider possibilities of growing beets in several new areas, also provides data on composition and the influence of environment and practices of fertilization and management on yield and quality of sugar beets.

The total research effort devoted to this work is about 1.6 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Sugar Beet Composition. Quantitative analyses for minor carbohydrate constituents of sugar beets in the presence of large amounts of sucrose have been quite difficult. Thin-layer chromatography is useful for qualitative but appears to have limitations for quantitative analyses. Paper chromatography promises to be suitable for analyses of both kestose and raffinose in beet juices. Gas chromatography of trimethyl silyl ethers of sugars has been a useful tool for quantitative analysis of beet sugars. Determination of raffinose using galactose oxidase was successful provided no other galactose-containing sugars such as melibiose or galactinol were present in the system. No galactinol was found in sugar beets from some samples from California, but when galactinol is present in stored beets awaiting processing it causes errors in measurement of sucrose. A new supply of galactinol for analytical reference purposes was prepared by a new method from syrup supplied by the Great Western Sugar Company. Innovations in the galactinol preparation include fermentation of sugars with yeast, conversion of reducing sugars to acid by oxidation, ion exchange, and ion exclusion. Ion exclusion appears to be a new useful technique for separating classes of sugar and for separating sugars from each other. For example, nystose (tetrose), kestose (triose), sucrose, glucose and fructose have been separated in laboratory-scale ion exclusion columns.

Information on enzymes involved in sucrose degradation in sugar beet tissue is being obtained at the Hebrew University, Jerusalem, Israel under P.L. 480. A detailed quantitative survey of several important intermediates in the carbohydrate metabolism of sugar beet root was conducted. Results indicate that the process of sucrose degradation in beet root is highly controlled and invertase is not involved. Sucrose cleavage is catalyzed by the enzyme synthetase at a rate such that sugar phosphates do not accumulate. This means some step in the sequence of sucrose degradation is limiting, and that step may be the first cleavage of sucrose. Fifty other enzymes have been shown to be active in sugar beets. Invertase activity was at a very low level.

B. New and Improved Products and Processing Technology

1. Juice Recovery and Purification. The sugar beet industry is concerned about the declining sugar extraction record of the past 20 years. Factory production records between 1943 and 1962 indicate that decreased production may be the result of lower sugar content of beets, lower purity of extracted juice, and the extension of the processing season. In most factories, sugar production can be predicted by use of equations involving sugar content of beets and thin-juice purity. In other factories, the cause of sugar losses is unknown. Decrease in sugar yield was substantial over the 20-year period for processors whose seasons were materially extended, giving rise to deterioration of the stored beets. Raffinose, kestose, galactinol, and reducing sugars increase at the expense of sucrose during beet storage at the factory.

Studies have been conducted to find conditions for storing beets that prevent accumulation of these non-sucrose carbohydrates.

Preliminary pilot-plant trials of the pressing of lime-toughened sugar beet pulp were conducted by informal cooperation with both a sugar beet processor and with a press manufacturer. Modifications in the continuous vertical screw presses now used are necessary before commercial application can be evaluated unless trials can be made using the latest type of large-scale, twin-screw horizontal press.

Ion exclusion is a way of separating sucrose from molasses impurities by means of an exchange resin that is already bonded with charged molecules. The separation occurs because the sucrose invades the porous resin while the charged impurities are excluded. The virtue of this method is that no expensive and damaging chemical regeneration of the resin is needed. Studies of ion exclusion purification of sugar-salt mixtures and molasses were conducted using a 6-inch by 10-foot steam-jacketed resin bed. Many runs were made to define the range of operating conditions for such variables as temperatures, flow rate, load volume, and solids concentration. The results are being analyzed by means of a digital calculator.

2. Sucrochemicals. The domestic Federal program of research on sucrochemicals was terminated in response to recommendations of the Sugar Research and Advisory Committee in 1963. Prior to termination of research on sucrochemicals, negotiations had taken place to provide P.L. 480 grants for work in this area. One such grant, to develop modified sugars that could be used for the synthesis of useful plastic substances, is still in progress at Jadavpur University in Calcutta, India. Principal activity during the past year has been to find an optimum reaction condition for synthesizing amino sucrose via hydrazino sucrose starting from mesyl and tosyl derivatives. So far, mixtures of amino compounds of only very low yields have been obtained. In a study of the differences in reactivity of hydroxyl groups of alpha-methyl galactoside compared with those of alpha-methyl glucoside, methylation of galactoside gave a very small amount of crystalline product. Four types of sulphate esters were obtained by adding a calculated amount of chlorosulfonic acid to sucrose in pyridine. Larger amounts of these esters will be prepared for further study.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition and Physical Properties

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NEW CROPS - UTILIZATION POTENTIAL
Southern Utilization Research and Development Division, ARS

Problem. Farmers could achieve more economic use of their land if new and profitable crops were available for their choice that would have different end-use patterns from those presently grown. For example, it would be advantageous to develop a new oilseed crop yielding unique fatty acids that could find industrial use in applications for which acids from presently available domestic oilseed crops are unsuitable. To develop a new crop, three basic steps are involved: (1) Survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential for use in the U. S.; (2) detailed physical and chemical characterization of components of interest to obtain clues to likely end uses; (3) selection of the most promising species followed by additional utilization research to explore uses and demonstrate industrial potential and by additional agronomic research to establish proper cultural practices and select the best strains and varieties. Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one. Yet, whether the future of agriculture involves conditions of surplus, of greater emphasis on foods and feeds, or of necessity for greater national self-sufficiency, the nation will benefit from availability of optimum, practical crop plants to serve its needs.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving an organic chemist engaged at the U. S. Fruit and Vegetable Products Laboratory, Weslaco, Texas, in research to determine the chemical characteristics of juices obtained from selected new varieties of sweet sorghum canes grown in the Rio Grande Valley of Texas, and the effects of cultural and harvesting practices on the chemical characteristics in relation to suitability for sugar recovery; close cooperation is maintained with Substation 15, Texas Agricultural Experiment Station, Weslaco, Texas for growing and harvesting the seeds provided by the Crops Research Division.

The Federal scientific effort at the Southern Division devoted to research in this area totals 1.3 professional man-years. All of this effort is on chemical composition and physical properties.

The following line of work was terminated during the year: Preparation of chemically modified fatty acids or oils, from the potential new oilseed crops Cuphea, Limnanthes, and members of the Umbelliferae, suitable for evaluation as corrosion inhibitors, biologically active compounds, in plastics, or other industrial products.

PROGRAM OF STATE EXPERIMENT STATIONS

Discovery and preservation of valuable plant germ plasm is a continuing objective of the station program in new crops. Much of the research in this area is being done via four regional projects and in cooperation with regional centers. A large portion of the work is cooperative with USDA. Each year many plant introductions are grown and evaluated. Annual and perennial crops possessing potential for industrial or agricultural use are further evaluated for agronomic and chemical qualities. These include crops for paper pulp, pigments, drugs, tannins, essential oils, insecticides, polysaccharide gums, and oils rich in acids of unusual structure. Assay of native and introduced tropical plants for products of economic value receives special attention. New varieties of fruits, vegetables, and grasses better resistant to disease and drought are continually sought.

Basic aspects of this program involve study of the biochemical and physiological basis for difference in crop plants. Attempts are made to determine if differences in biochemical or physiological processes can be associated with particular factors related to quality. Information concerning carbohydrate transformations is sought through study of carbohydrate formation and enzyme mechanisms. Horticultural specialty crops are gaining in importance. A number of studies are underway to facilitate rapid development of this industry.

The total scientific effort devoted to replacement crops is 8.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition and Physical Properties

1. Investigations of Chemical Characteristics of Sweet Sorghum to Evaluate Its Potential for Recovery of Sugar. Since sweet sorghum is needed as a replacement for crops subject to freeze and as an aid to the Rio Grande Valley's overall economic stability, investigations of the chemical characteristics of new sweet sorghum canes have been initiated to determine whether it is possible to grow and process them for sugar. Field tests were designed to evaluate variety, time of planting, and soil requirements. Most of the 430 samples of juice pressed from sweet sorghum from the 1964 date-of-planting field tests have been analyzed for Brix, pol, and apparent purity to permit agronomic evaluation of the cane varieties and to determine the length of the season during which they can be grown to produce satisfactory quantities of sugar. Analyses of many of these materials for their true dry solid and invert sugar contents have also been made as a basis for calculating juice impurities such as starch, organic acids, and minerals. However, many of these data require checking for three to five seasons before reliable estimates and recommendations can be made about variables that influence a specific variety's potential production of sugar. (S5 5-51).

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

None.

NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers change constantly with the adoption of new practices of production, processing, and marketing. Changing constantly also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise consumers on the quantity and variety of foods that will assure maximum benefit and satisfaction, research must continue on the nutritional requirements of persons of all age groups, on the nutrient and other values of foods, and on how to conserve or enhance these values in household and institutional preparation and processing. Periodic surveys of the kinds, amounts, and costs of foods consumed by different population groups and individuals also are essential to evaluate the nutritional adequacy of diets and to give the guidance needed for effective programs of nutrition education. Information from such surveys provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and consumer use.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care, and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service -- the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville and Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas is 77.5 man-years. It is estimated that 1.4 man-years is concerned with studies related to sugar.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 30.2 professional man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to dietary carbohydrates are considered briefly in this report.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Nutrient value of foods. Research on the nutritive composition of food is often concentrated on locally produced commodities. Much of the evaluation is related to changes induced by growing practices, processing and storage.

The total program in this area includes 38 projects in 24 States and is comprised of approximately 27.3 professional man-years.

Properties related to quality and consumer use of food. Research on food preparation for consumer use may be accompanied by measures of quality from the raw state, through handling and processing for marketing, to final home and institutional service. Special measures characterize certain classes of products; e.g., vitamin assays, enzymatic activity, water binding capacity, and changes in structural tissues.

The structure of baked products as related to the physical and chemical properties of the starches used and supplementary products involved, as fats and sugars are the subjects of ongoing basic research in the carbohydrate area. The physical structure of frozen and stored batters and doughs is under study.

The State program in this area includes 55 projects in 27 States and involves approximately 50.5 professional man-years. This is a partial report of the State Experiment Station program in food science and includes the work undertaken and participated in by Departments of Home Economics. For research on food and fiber, see the reports of the Utilization Research and Development Divisions, and Clothing and Housing Division.

Food consumption and diet appraisal. The State program in food consumption and diet appraisal extends the work of the Department to selected segments of the population or to smaller geographic areas. One continuing investigation in the North Central Region is planned to yield information regarding food purchase and consumption patterns of families with preschool children. This research will provide information of use to both consumer education and

market interests. A continuing consumer panel in a Southern metropolitan area is providing information on purchase patterns, including data on changes in form, amount, kind, expenditure, and nutritive value of foods purchased. Attempt is made to identify and quantify in a relative sense the factors effecting change.

Currently 16 States are contributing to the Experiment Station program in this area which totals 22.7 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Nutrient and other Consumer Values of Food

1. Tables of food composition. A table is being developed that will give nutritive values for many of the foods in Handbook No. 8 in terms of market units of the items as usually purchased and in terms of household measures of prepared foods. The data needed to prepare this supplement to the 1963 edition of the Handbook are being obtained through consultation with representatives of industry and of Consumer and Marketing Service as well as through observation of products offered for sale.

Research findings compiled from the world's literature on the nutritive value of foods continue to be in constant demand as background material for dealing with a wide variety of problems. For example, technical assistance was given in the development of policy and guidance for the Food for Peace Program, and in the development of educational materials on the so-called convenience foods for the use of dietitians in teaching diabetics. Information on the composition of specific foods or groups of foods was also given to research teams conducting dietary surveys, to welfare workers and to agencies of the Federal Government such as the Federal Trade Commission, the Food and Drug Administration, and the National Institutes of Health. Within USDA, information was provided for revising several tables in Statistical Bulletin No. 362, Conversion Factors and Weights and Measures for Agricultural Commodities and Their Products, issued in June 1965.

B. Nutritional Evaluation of Dietary Carbohydrate

Research in the Department and elsewhere has provided evidence that the kind of carbohydrate in the diet may influence metabolism under some conditions, and that the changes may be due to an interaction with other dietary ingredients. Research is continuing to find out more about the interactions of fats and proteins with different kinds and amounts of carbohydrates, their effects on body composition, and on the structure and functioning of tissues at various stages of the life cycle.

1. Kind of carbohydrate. Research to determine the influence of source of dietary carbohydrate on selected enzymes in the tissues is providing further information that may help in understanding differences that occur in the

physiological and biochemical response to different carbohydrates and aid in explaining the variations in response to diet among individuals. The results to date indicate that both heredity and diet may influence the concentration of some of the tissue enzymes involved in carbohydrate metabolism and fat synthesis. The diets under investigation are identical in all respects except the kind of carbohydrate. The carbohydrates include two simple sugars, glucose and sucrose, and a complex polysaccharide, cornstarch. Two strains of rats known to differ in their lipid metabolism are being used for this study. The activity of glucose-6-phosphate dehydrogenase, an enzyme involved in carbohydrate metabolism and fat synthesis, was found to be significantly higher in the livers of young animals fed sucrose than in those fed the cornstarch-containing diet. Heredity was also found to influence significantly the activity of β -glucuronidase and alkaline phosphatase in the liver as well as the activity of glucose-6-phosphate dehydrogenase. The results were reported at the meeting of the Federation of American Societies for Experimental Biology in April and a paper for publication is in preparation.

A study was initiated on the metabolic response of 10 young women to controlled diets in which approximately 85% of the carbohydrate is provided either by sucrose or by wheat starch. Response is being studied in terms of intake and output of nitrogen, fat, and selected minerals, blood serum protein components, blood serum enzymes, blood serum lipid levels, and the fatty acid patterns in the cholesterol, phospholipid, and glyceride fractions of the blood serum.

2. Protein - carbohydrate interrelationships. To obtain further information on the metabolic interrelationships among nutrients, a project has been initiated to investigate at the cellular level possible interactions between nitrogen and carbohydrate. For these investigations Tetrahymena pyriformis will be used to investigate the influence of varying the kind and level of carbohydrate through measurements of free amino acids and protein components in the cells, and selected enzymes active in the utilization of carbohydrates. Carbohydrates to be included are two simple sugars, glucose and fructose, and the more complex dextrin from cornstarch.

3. Lipid - carbohydrate interrelationships. In research recently completed under contract at the Children's Hospital of the East Bay in Oakland, California, it was found that during the period of rapid growth the concentration and composition of lipids in blood serum was affected to a greater extent by the kind and amount of dietary fat than by the type of dietary carbohydrate. The young puppy was chosen as the experimental animal for these studies because it had been shown that puppies reacted to diets low in linoleic acid in a manner similar to the response of young infants. Experimental diets were prepared to simulate infant formulas. All serum lipid fractions were significantly lower when very small amounts of fat rather than moderate amounts of fat were fed, irrespective of type of carbohydrate (sucrose, dextrimaltose, corn syrup, and beta lactose). Total

and glyceride fatty acids were lower when a moderate amount of fat was provided by corn oil than when the same amount was provided by hydrogenated coconut oil. The lipid metabolism of puppies was little influenced by the kind of dietary carbohydrate. The only significant effect of the four dietary carbohydrates studied was on serum cholesterol levels, which were lower on sucrose diets than for other dietary carbohydrates regardless of whether corn oil or hydrogenated coconut oil was the dietary fat. All of the carbohydrates investigated, except lactose, were suitable as a source of dietary carbohydrate. With lactose, puppies grew poorly, diarrhea occurred, and mortality rate was high regardless of amount and type of dietary fat. The inability of these animals to utilize lactose was interpreted as due to lack of lactase in the intestinal mucosa, an enzyme needed for the absorption and utilization of this sugar and known to be available to the human infant. A report of this research has been accepted for publication in the July issue of the Journal of Nutrition.

The interaction of dietary, genetic and hormonal factors is being studied in adult persons found susceptible to carbohydrate- or fat-induced high blood lipids in a PL 480 project in Israel. They are studied when on diets low in fat and high in starch or sugars, and when on diets low in carbohydrates and high in different types of fat.

C. Food Consumption and Diet Appraisal

1. 1965 nationwide survey. A nationwide survey designed to provide information on the food consumption and dietary levels of people in the United States is now underway. Data on the kinds and quantities of food used during one week were collected under contract from more than 7,500 representative U.S. households between April 7 and July 3. Similar data will be obtained from 2,500 households each in the summer and fall of 1965 and the winter of 1966. Information on the food eaten both at home and away from home during one day was provided by 13,000 individuals who were members of the families providing information on household food consumption during the spring of 1965. The study was designed to provide data for the four Census regions for farm, rural nonfarm, and urban populations for the year as a whole and for the four seasons.

Detailed tabulation plans have been drawn up that will provide for a series of volumes on the household data obtained in the spring of 1965 similar to those published for the 1955 survey. Other tabulation plans will provide information on (1) the 12-month period April 1965-March 1966 and for the four seasons, (2) the relationship between the money value of household food and its dietary adequacy, and (3) the intake of both food and nutrients of individuals by age and sex.

2. Effects of food distribution programs on diets of needy families.

Analyses of data from studies in Detroit, Michigan, and Fayette County, Pennsylvania, conducted to obtain information on the effectiveness of the Food Donation and Food Stamp Programs showed the following. (1) Many of

the families participating in the Food Donation Program failed to participate in the Food Stamp Program when it replaced the Donation Program. The families who did participate in the Food Stamp Program were usually those of younger homemakers with more formal education, more young children, and lower incomes for family size. (2) Calcium and ascorbic acid were the nutrients which increased most when the Food Stamp Program replaced the Food Donation Program. They were also the nutrients in which diets were most limited (according to the National Research Council allowances) under both the Food Stamp Program and the Food Donation Program. (3) The overall quality of diets was better under the Food Stamp Program than under the Food Donation Program. (4) Under the Food Stamp Program participants received coupons which would purchase food worth considerably more in money than the foods received under the Food Donation Program--approximately 135 percent more in Detroit and 65 percent more in rural Fayette County. They were also able to make their own selections.

A study of families participating in the Food Donation Program in Baltimore showed that little or no dietary improvement occurred when the number of donated foods was increased from five to eight. Families cut back on their food purchases, apparently using the funds thus made available for other needs.

3. Nutritive value of national food supply. The revision of estimates of the food energy, protein, fat, carbohydrate, and calcium, phosphorus, iron, vitamin A, thiamine, riboflavin, niacin, and ascorbic acid content of the per capita food supply from 1909 to the present has been completed. The revised figures incorporate newest estimates of per capita food consumption developed by the Economic Research Service, revised food composition data from Agriculture Handbook No. 8, and new information on the nutrients added to foods by enrichment and fortification.

The revised estimates and tables showing the contribution of major food groups to the total supply of each nutrient for selected years were published as Chapter 5 of Statistical Bulletin No. 364, "U.S. Food Consumption--Sources of Data and Trends," Economic Research Service, June 1965.

The estimates for nutrients together with the per capita food quantities on which they are based are extremely useful in studying dietary trends.

4. Support for food and nutrition programs. The compiling and interpreting of research-based information on nutrition for application to problems of food selection and food use is continuing. The information so developed serves as a basis for assistance to many groups both within and outside the Department. For example, technical advice and guidance were given during the year to the School Lunch Division, Consumer and Marketing Service, in revision of two publications designed to help improve the nutritional quality of school lunches. Also assistance was given to the Office of Economic Opportunity in the preparation of "Nutrition Guidelines" for the Project Head Start Centers Feeding Program.

Publication of Nutrition Program News and participation in the Interagency Committee on Nutrition Education, for which CFE furnishes the secretariat, are continuing as a means of coordinating and strengthening nutrition programs in general. A noteworthy accomplishment was the development by the Committee of four basic nutrition concepts to be used as guidelines for program planning and curricular development in nutrition education.

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III. MARKETING AND ECONOMIC RESEARCH

ORGANIZATION AND PERFORMANCE OF MARKETS Marketing Economics Division, ERS

Problem: Economic research in agricultural marketing revolves around the problems of increasing efficiency in the processing and distribution system and providing a foundation for orderly adjustments to changes inside and outside of agriculture. Marketing must be looked upon as a dynamic and changing process. The capacity to adjust to and cope with the dynamics of modern marketing is required increasingly of producers and distributors of farm products. Demands of a more knowledgeable and sophisticated consuming public are adding to the pressures for an even more rapid escalation of developments and changes within the marketing system. Changes in institutions and redirection of public policies and programs are modifying the economic environment in which marketing firms must perform and operate. Because of rapid changes and increasing complexities associated with a dynamic marketing system, it is necessary that a continuous program of research be conducted in marketing--a program aimed at keeping producers and marketing firms abreast of the flow of events and providing information necessary to them in making proper and orderly adjustments to change.

Research in the area of organization and performance of markets is designed to find solutions to economic problems of marketing, including the transportation of farm products. Such studies furnish a basis for adjusting to change and keeping abreast of technological and scientific developments. Likewise, the studies provide a sound basis for both private and public policy decisions as they relate to marketing.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing long-term program of economic research designed to increase the efficiency of marketing and assist producers and marketing agencies in adapting to a changing environment. Research is conducted on a wide range of functional and commodity problems that arise in moving farm products from producers to consumers. The program involves both basic and applied research and is primarily oriented to problems of national and regional scope. Field studies are often conducted jointly with State agricultural experiment stations, with processors and distributors of agricultural products, transportation agencies, and agriculturally-oriented trade groups. Producer groups and trade organizations have, with increasing frequency, made financial contributions to the Division research efforts. Many staff members are working closely with the staff of the National Commission on Food Marketing in a consultative role and in research studies on price spreads and market structure. These studies are partly financed by the Commission.

The Department's program of research and related reporting activities are conducted from headquarters in Washington, D.C., with a limited number of field stations located throughout the United States. In addition to conducting research, field station personnel perform a special service in keeping the Division alerted and informed on emerging and significant problems in marketing.

In the overall area of organization and performance of markets, the scientific effort devoted to this research in the past year amounted to approximately 78 professional man-years. By functional subareas the research effort in professional man-years was distributed as follows: Market institutions and market power, 26; prices, costs, and margins, 40; and, location and interregional competition, 12. (Of this research effort approximately 2.5 professional man-years were devoted to sugar.)

PROGRAM OF STATE EXPERIMENT STATIONS

A. Market Institutions and Market Power

Changes in the structure of marketing agricultural products affects the bargaining power of buyers and sellers. These changes also affect marketing practices, services and prices--and ultimately producers, marketing firms and consumers. Research underway at the State stations deals with these changes and some possible alternatives.

B. Prices, Margins and Costs

Prices and marketing margins are continually being examined in light of changes in production, processing, storing, transporting, and distributing agricultural products. Historically, retail prices have increased relatively more than farm prices which is a reflection of increased marketing services of many products. There is a high degree of public and legislative interest in this research being conducted by the State stations.

One station is investigating costs of hauling sugarcane in motor trucks and alternative methods of compensating growers. It uses 1.6 professional man-years.

C. Location and Interregional Competition

Changes in the technology of producing and processing agricultural products has much impact on the comparative advantage of one producing area over another. Changes in transportation rates and costs also affect the competitive position of some areas more than others. These changes and their effects on the location and interregional competition are being studied by the State stations.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Market Institutions and Market Power

The structure of markets for agricultural products is changing in many dimensions and the market power of buyers and sellers and practices of marketing firms are shifting in response. All these changes have significant impacts on farmers, consumers, and marketing agencies. The Marketing Economics Division conducts studies on many phases of this changing market.

Rapid changes have occurred in recent years in marketing sweeteners in the United States and in the apparent market power of various groups marketing sugar and other sweeteners. These changes include the increased use of noncaloric and corn sweeteners in the United States, the slowing of growth in the consumption of sugar, increased production of sugar in continental United States, and a worldwide shift from a shortage of sugar and high prices to a surplus and low prices. The net effect of these changes has been to weaken the market position of the domestic sugar industry and the importers of raw sugar. Information concerning the current status and potential position of noncalorics in the sweetener industry is being studied.

B. Prices, Margins, and Costs

In the last decade, prices to consumers for most products of farm origin have risen despite downward trends in farm prices. This widening of farm-retail spreads has brought widespread public concern about the efficiency and performance of the marketing system which culminated in the establishment of a National Commission on Food Marketing.

Higher sugar prices in 1963 and early 1964 increased growers' returns moderately. While sugar prices during the first half of 1965 have been below the levels reached in 1963 and early 1964, they are about one-half cent per pound above the 1962 average. This indicates that growers' returns for their 1965 crop may be slightly below the level of the last two years.

Relatively high prices for industrial molasses, especially in 1963 and early 1964, caused significant changes in utilization. Since World War II petroleum gases have replaced molasses as the major raw material in the production of industrial alcohol. Molasses in each of its major uses is subject to effective competition from alternate raw materials. In livestock feed other materials such as milo, corn, and bran may be substituted for molasses. Dextrose has recently been substituted for molasses in the production of citric acid by a major producer.

C. Location and Interregional Competition

As farm production shifts from one area to another, marketing firms must adjust to the new environment. New firms may be called for in one area while those in other areas must seek other opportunities. Changing transportation rates put one area at a competitive disadvantage compared to others both in production and marketing. Marketing economic studies emphasize the changes taking place and the scope of adjustments needed to meet them.

Increased production of beet sugar, primarily in the West, relative to total sugar consumption in the United States has caused shifts in the proportion of beet sugar marketed in various areas and in price relationships among various marketing territories. The increase in transportation cost because of shipments for longer distances has reduced the average net returns per unit somewhat below what otherwise would have been expected.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Market Institutions and Market Power

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COOPERATIVE MARKETING

Farmer Cooperative Service

Problem: Farmers continue to increase their use of cooperative marketing.

These cooperative operations are conducted in a marketplace where handling and processing, transportation, and distribution technology is changing rapidly, and market organization and practices are undergoing major changes. Farms themselves have changed. Farmers and their cooperatives need research results that relate to these developments and new conditions to assist them in marketing efficiently. Such research will assist farmers to strengthen their bargaining power, increase marketing efficiency, and meet effectively the quality, quantity, and service needs of today's food and fiber marketplace.

Cooperative marketing is a direct and major way for farmers to get maximum returns from their products. Farmers own and operate cooperatives specifically to increase their income from crops and livestock. Gains are not automatic, however. Cooperatives must plan and actually conduct the specific marketing program and services that will yield best returns for their members. Marketing cooperatives must know what the consumer demands, as reflected in the market. They must be able to estimate the cost of serving the market in different ways. They must understand the possibility of major economies in a well-managed joint sales program, and understand the methods and potentials of bargaining. Management must achieve minimum costs through appropriate organization, good use of existing plant and personnel, and the correct selection and use of new equipment and methods.

USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation, and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D.C. Many of the studies, however, are done in cooperation with various State experiment stations, extension services, and departments of agriculture.

Federal professional man-years devoted to research in this area totaled 19.6. Of this number, 0.9 was devoted to citrus, 1.4 to cotton, 3.8 to dairy, 1.4 to deciduous fruits, 1.7 to grain, 2.0 to livestock, 2.2 to oilseeds, peanuts, and sugar, 1.2 to potatoes, 3.0 to poultry, 1.5 to vegetables, and 0.5 to wool.

Research also is conducted under contract with land-grant colleges, universities, cooperatives, and private research organizations. This report includes work conducted during the present period, or release of results of

work earlier completed, through contract research performed by universities in Iowa, Montana, North Dakota, and West Virginia, and by two private research companies.

STATE EXPERIMENT STATION PROGRAM

Most of the commodity marketing research of the agricultural experiment stations is helpful to marketing cooperatives. Some projects, however, deal specifically with cooperative marketing problems, opportunities, and impacts. At the present time 10 States have 12 research projects in cooperative marketing. Their commodity distribution is as follows: grain-2, tobacco-1, fruit and vegetables-1, livestock-2, and cross-commodity-6.

Some projects evaluate the performance and organizational features of cooperatives. Different methods of pooling and their problems are studied so as to develop helpful principles. In the analysis of cooperative operations and in working with directors and managers, efforts are made to identify and solve the many problems that are arising. Particular attention is given to what services or functions should be provided by cooperatives. There is interest in learning more about the attitude of members and nonmembers toward cooperative marketing, especially the differences in these attitudes.

In the last few years more attention is being given to the role of cooperatives in achieving bargaining power for farmers. In connection with market structure studies, special attention is being given to the impact of cooperatives on market conduct and performance.

The total research effort on cooperative marketing in the 10 States is 2.5 professional man years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Improving cooperative sales, distribution, and pricing methods

Wholesale and retail marketing practices are continuing to change rapidly, and there have been fundamental changes on the farm. For these reasons sales and distribution and pricing methods need to be studied carefully to plan and realize methods and policies that are technically efficient and obtain good returns for producers. Bargaining methods and pooling are two topics that require major research emphasis. Research on these problems included work in several commodities.

Bargaining (dairy, deciduous fruit and tree nuts, eggs, poultry, sugar beets, and vegetables). Research concerning bargaining methods and results was expanded to include dairy, egg, poultry, and sugar beet bargaining. This research seeks to appraise the status, role, and potentials of cooperative bargaining as a means of stabilizing and enhancing the incomes of producers.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

None.

